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CHROMOSOMAL STUDIES IN ERI SILK MOTH, *PHILOSAMIA RICINI* HUTT. (LEPIDOPTERA, SATURNIIDAE)

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(*Received 10 January 1979*)

The present investigations have been carried out using air-dry Giemsa technique. In this species the diploid chromosome number is 28 in both the sexes. All the chromosomes intergrade in length ranging from 1.2μ to 2.8μ at spermatogonial metaphase. The secondary constriction was observed in a smaller pair of chromosomes. The meiosis in male is chiasmatic while in female, it is achiasmatic. The average chiasma frequency per cell at early diakinesis is 27. All the chiasmata are terminalized by the end of diakinesis. Besides, the sex chromosomes and nature of chromosomes during mitotic and meiotic stages have been discussed.

(*Key words :* **chromosomes of eri silkmoth, *Philosamia ricini***)

INTRODUCTION

Although more than 1000 species of Lepidoptera are cytogenetically known by their chromosome numbers (ROBINSON, 1971; ENNIS, 1976), other cytogenetical aspects have been studied only in a few species (ROBINSON, 1971; TRAUT & RATHJENS, 1973; MURAKAMI & IMAI, 1974; BIGGER, 1975, 1976; GOODPASTURE, 1976; TRAUT, 1976). In male eri silk moth, *Philosamia ricini* a preliminary cytogenetical study has been made by KAWAGUCHI & YOSIDA (1953), DEODIKAR & THAKAR (1958), SRIVASTAVA & GUPTA (1962), and YUNG (1962). The chromosome number (2n=28) in male of this species has been established by them. Chiasma formation in bivalents in male meiosis has also been reported by DEODIKAR & THAKAR (1958). The present investigations in this species have been made on germinal tissue of both the sexes.

MATERIALS AND METHODS

Philosamia ricini was reared in laboratory conditions. The gonads were dissected out from 3rd to 5th instar larvae and from prepupal stages (meiosis commences in 4–5th instar in both the sexes: in the male it is completed by mid-pupal stage: in the female it is arrested at late prophase till the eggs are laid). After a pretreatment in hypotonic solution (0.9% sodium citrate) for 15–20 minutes, the tissue was fixed in methanol-acetic acid (3:1) for 30 minutes. The preparations were made by smear technique as follows: A bit of tissue was placed on a prewarmed slide (40°C) in 2–3 drops of 60% acetic acid, teased with fine needles and the cells were, thus, liberated to form a smear which was then either air dried or heat dried (50°–60°C). The smears were stained in 2–8% Giemsa (diluted in M/15 Sorensen's phosphate buffer, pH 6.8) for 30–40 minutes at room temperature. For karyotypic analysis the measurements of chromosomes were made from the photographs' projections with the help of epidiascope at a magnification of about 3000.

RESULTS

The chromosome number (2n=28) in both the sexes has been established in the several stages of mitosis and meiosis studied (Figs. 1–8). The karyotypic analysis could be made at mitotic late prophase (Figs. 2 & 3). The chromosomes intergrade in length. In the karyotype, analysed from 11 cells, the chromosomes have been arranged

in decreasing order of length, considering mean percentage length of individual chromosomes with respect to the total length of the complement, which is 10.4, 8.9, 8.4, 8.4, 7.8, 7.8, 7.3, 7.3, 6.8, 6.8, 6.3, 5.8, 4.7, and about 3.2 (unequal homologues) percent respectively. The 13th pair reveals a secondary constriction in each homologue clearly in the male.

In both the sexes, the chromosomes during premetaphase reveal moderate separation of sister chromatids which seem parallely aligned, thus, probably indicating precocity in the division of their centromeric regions (Fig. 4). At metaphase (Fig.1) the chromosomes become much condensed, their actual length ranging from 1.2 to 2.8μ in the male. The chromosomes occupy whole of the area of the metaphase plate.

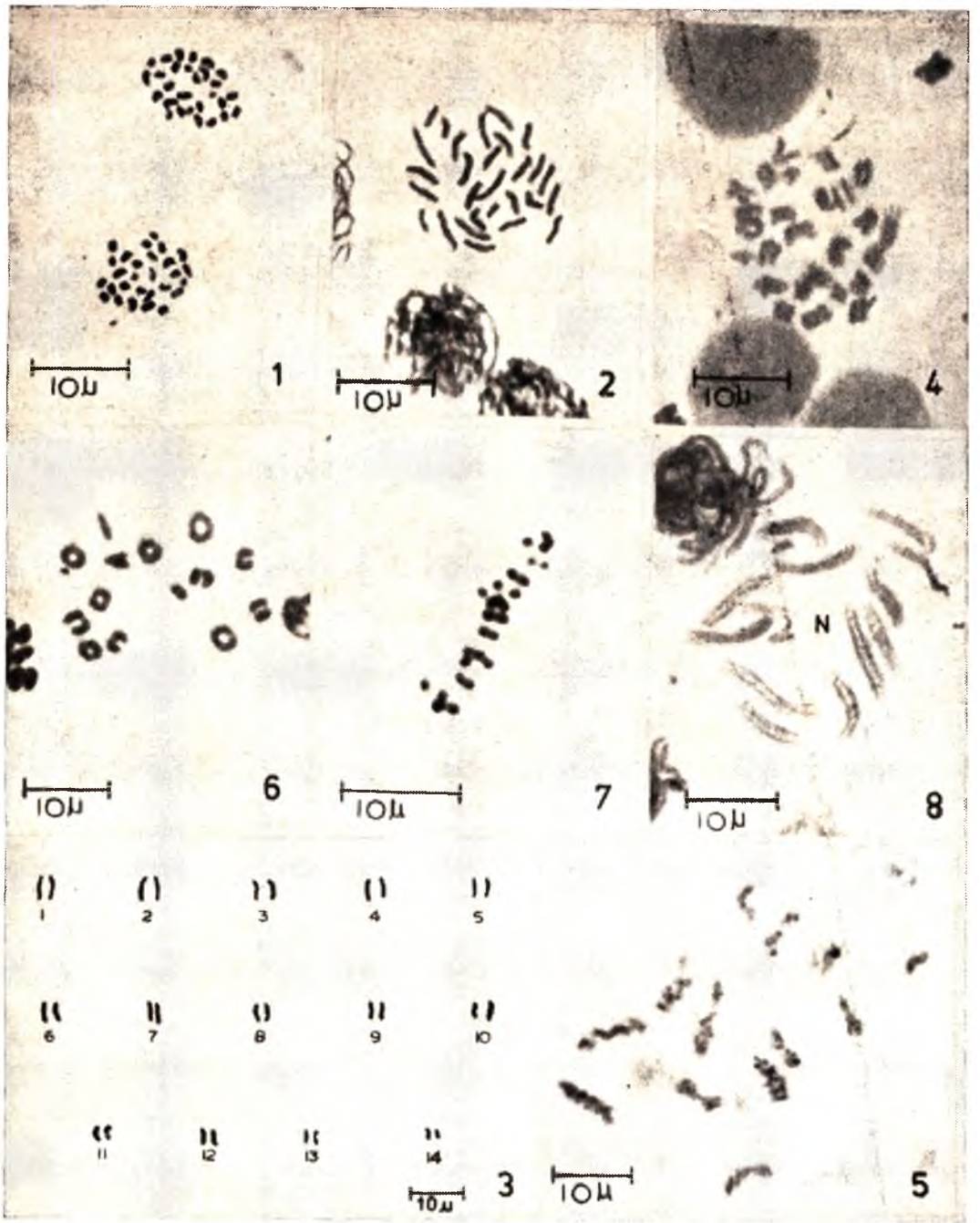
In male, during prophase I upto early diakinesis a positively heteropycnotic body is visible. This body has been observed to be a part of a small-sized nucleolar bivalent and associated with the nucleolus as seen from diplotene (Fig. 5) to early diakinesis. The chromosomes at early diplotene are moderately diffused and rough in outlines. At early diakinesis the number of chiasmata per bivalent range from 1 to 2, the mean chiasma frequency per cell comes to 27.4, and the terminalization coefficient is 0.82. The terminilization of chiasmata is completed by the end of diakinesis (Fig. 6). At metaphase the bivalents become so much condensed that they appear dumbbell shaped and are co-oriented (Fig.7).

In female, the prolongation of parallel pairing of homologous chromosomes, with concomitant suppression of diplotene-diakinetic 'opening out' occur in all the bivalents. A clear reductional split has been observed in each bivalent up to the end of prophase indicating achiasmatic nature of the bivalents. During early prophase a positively heteropycnotic but smaller body is visible in a small bivalent while during mid-prophase (Fig. 8) the same bivalent is seen to be associated with nucleolus by a secondary constriction in one of its homologues at the same location where the heterochromatin is observed at early prophase.

DISCUSSION

DEODIKAR & THAKAR (1958) reported to have observed two larger pair of chromosomes having distinct satellites or secondary constrictions. In our findings it is only one smaller pair of chromosomes which has got secondary constriction and was found associated with the nucleolus in both the sexes. In case of *Philosamia cynthia,* DEDERER (1907) also reported but one pair of nucleolar chromosomes. From the improved cytological technique, we could also observe sexual dimorphism in this species with respect to nucleolar bivalent-there being a pair of these in the male and a single in the female. From this it seems probable that this bivalent showing dimorphism represents the sex chromosome pair-the nucleolar chromosome representing the 'Z' and the nonnucleolar one the 'W'. This therefore shows heterogamety in female sex as reported by SUOMALAINEN *et al.* (1973) in Lepidoptera. The sex chromatin was not observed in interphase of any of the sexes.

The primary constrictions reported by DEODIKAR & THAKAR (1958) in diplotene stages could not be observed in mitotic or meiotic stages of either sexes. Secondly the prometaphase and metaphase chromosomes also do not show a clear primary constriction. Due to the non-availability of appropriate mitotic anaphases the nature of chromosomes however could not be established.



Figs. 1 to 8: 1. Mitotic metaphase ♂ (polar view); 2. Mitotic late prophase ♂; 3. Karyotype prepared from Fig. 2; 4. Mitotic premetaphase ♀; 5. Diplotence ♂; 6. Late diakinesis ♂; 7. Metaphase I ♂ (side view); 8. Mid prophase I ♀ (N = nucleolus). Figs. 1–4 and 6–8 after staining in 2-3% Giemsa. Fig. 5 after staining in 8% Giemsa.

Generally the meiotic mechanism in Lepidoptera is chiasmatic in the homogametic (male) sex and achiasmatic in the heterogametic (female) sex (SUOMALAINEN *et al.*, 1973). The similar meiotic mechanisms have been discovered in *Philosamia ricini* by the present authors.

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EFFECTS OF ENDOSULFAN ON THE MEDIAL NEUROSECRETORY CELLS OF ADULT MALE *ODONTOPUS VARICORNIS* (DIST.) (PYRRHOCORIDAE : HETEROPTERA)

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(*Received 3 March, 1979*)

Injection of LD_{50} doses of endosulfan into the young adult male *Odontopus varicornis* has produced marked changes in the structure and the secretory activities of medial neurosecretory cells. These cells, after an hour of treatment, exhibit a more intense staining reaction and have a higher nucleoplasmic index value. A reduction in the staining reaction and nucleoplasmic index value is observed after two hours of treatment and at moribund stage. It appears that endosulfan stimulates the synthetic activity of these cells at the initial stage of its action and this results in the accumulation of neurosecretion in the cytoplasm of these cells. The decrease in the amount of neurosecretion at later stages of the action may be explained on the basis of its transportation through the axons of these cells before the death of treated insects. Vacuolization and shrinkage of these cells are also observed.

(*Key words : Odontopus varicornis*, **medial neurosecretory cells, endosulfan, LD_{50} dose, secretory activity**)

INTRODUCTION

Several authors have contributed to our understanding of the role of neurosecretory cells in the control of different physiological activities in insects of different orders (VAN DER KLOOT, 1960). However, studies on the effects of insecticides on the neurosecretory cells of the brain appear to be limited to a few species of insects (SHARMA, 1966; MASNER *et al.*, 1970; NANDA, 1974; TAN, 1976; JALAJA & PRABHU, 1977). The present work is aimed at finding out the effects of an organochlorus insecticide, endosulfan, on the secretory activity of medial neurosecretory cells (MNC) of the adult male, *Odontopus varicornis*.

MATERIALS AND METHODS

Young adult male insects were injected each with 0.075 ml of LD_{50} doses (0.002143 μg/g) of endosulfan into the intersegmental thoracic region (SABESAN & RAMALINGAM, 1979). These insects were, then, vivisected in insect saline solution, at an interval of one hour upto moribund stage i.e., 3-4 hr after injection. The brains of the ireated insects as well as the control ones were fixed in Bouin's fluid, embedded in paraffin wax, sectioned at 6-8μ thickness and stained with paraldehyde fuchsin (PAF) technique (EWEN, 1962). The secretory activity was determined from the volume of thier nuclei (LEA & THOMSEN, 1962; RAMALINGAM, 1971) and the nucleoplasmic index (NP) values (Tan, 1976).

RESULTS

The cytometric data of MNC of endosulfan treated insects and of control ones are graphically represented in Fig. 1. The pars intercerebralis part of the brain of this insect contains four types of MNC namely, A,B,C and D cells (KAMALAKANNAN, 1977). A–cells, which are relatively more conspicuous than the other cells, show marked changes in their structure and secretory

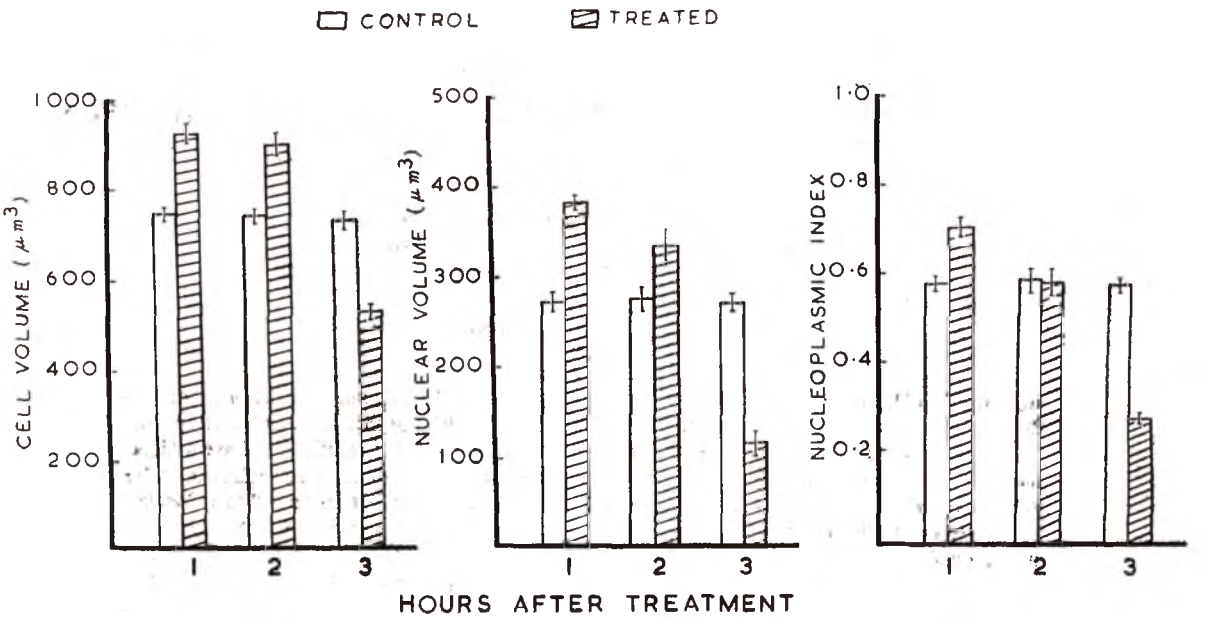

Fig. 1. Cytometric values of MNC of control and endosulfan treated insects. Standard errors are shown.

activities as a result of treatment with endosulfan. The MNC of control insects show a moderate staining reaction with PAF (Fig. 2) and have a nuclear volume of $271.32 \pm 20.4\ \mu^3$ and NP value of 0.581 ± 0.032. On the other hand, these cells, after an hour of treatment, exhibit an intense staining reaction with PAF (Fig. 3) and have a maximum nuclear volume of $381.85 \pm 16.8\ \mu^3$ ($P < 0.05$) and NP value of 0.707 ± 0.043 ($P < 0.05$). A reduction in the staining reaction with PAF, nuclear volume ($333.17 \pm 34.7 \mu^3$) and NP value (0.582 ± 0.062) is observed in the MNC of the insects after two hours of treatment (Fig. 4), and at moribund stage (Fig. 5). The cytometric values in these stages of treatment are found to be significant. The MNC, at moribund stage, show considerable shrinkage, and vacuolization in their cytoplasm.

DISCUSSION

The secretory activity of the MNC of *O. varicornis*, at the initial stage of endosulfan treatment, has been increased as indicated by an increase in nuclear volume and NP values. It may be inferred from these observations that endosulfan appears to stimulate the synthetic activity of these cells and this results in the accumulation of neurosecretory materials (NSM) in their cytoplasm. MASNER *et al.*, (1970), using reserpine and TAN (1976), using hemel and tepa have reported that the treatment with these chemosterilants has resulted in the increase of the concentration of neurosecretion in the MNC of *Tenebrio molitor* and *Ephestia kühniella* respectively, and considered that this increase was due to an accumulation of NSM. The chemosterilant, apholate has also been

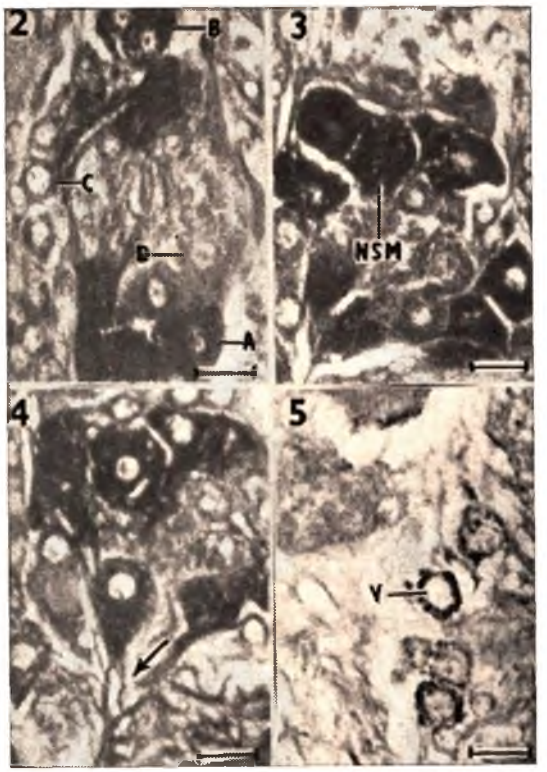

Fig. 2. Section of the brain of control insect showing four types of neurosecretory cells (A, B, C and D) ; Scale: 20μ. Fig. 3. Section of the brain of endosulfan treated insect (1 hour) showing A–cells with higher concentration of neurosecretory materials (NSM) Scale: 20μ. Fig. 4. Section of the brain of endosulfan treated insect (2 hours) showing the release of neurosecretory materials through the axons (arrow), Scale: 20μ. Fig. 5. Section of the brain of moribund insect showing A–cells with low concentration of neurosecretory materials. Note the shrinkage of the cells and vacuolization (v) in their cytoplasm, Scale: 20 μ.

shown to produce similar effects in *Dysdercus cingulatus* (JALAJA & PRABHU, 1977). These findings point out that some of the insecticides such as those referred to above seem to interfere with synthetic activity of neurosecretory cells or the release of their synthetic products, with the result that neurosecretion increases in its concentration in these cells. The secretory activity of MNC of *O. varicornis* at the later stages of the action of insecticides is found to be reduced as evidenced by a decrease in the nuclear volume and NP values. The insecticide, endosulfan, thereby appears to stimulate the MNC at the later stages of its action to release their synthetic products (NSM) through the axons, and this accounts for a decreased quantity of NSM present in MNC at moribund stage. NANDA (1974), while studying the impact of insecticides on the brain neuroglandular elements of *Periplaneta americana,* has suggested that the treatment with endrin and sumithion resulted in the eventual exhaustion of NSM through the axonal tracts. Endosulfan, in addition to these effects, has produced certain histological changes such as shrinkage and vacuolization in the MNC of of *O. varicornis*. These observations are consistent with those of SHARMA (1966) and NANDA (1974) who have reported for *Poecilocerus pictus* and *P. americana* respectively, that the treatment with certain insecticides causes shrinkage and vacuolization of the neurosecretory cells.

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STERNAL GLAND AND MECHANISM OF TRAIL-LAYING IN THE TERMITE *POSTELECTROTERMES NAYARI* (ISOPTERA : KALOTERMITIDAE)

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In *Postelectrotermes nayari*, the sternal gland is seen as an epidermal thickening on the fifth abdominal sternite below the fourth abdominal ganglion. The gland is highly developed in pseudergates and less developed in nymphs and reproductives. Two types of cells are distinguished in the gland. No duct opening to the outside could be found. Ether extract of the sternal gland region elicited trail-following in members of the same species.

(*Key words* : **sternal gland, trail-laying pheromone, pseudergate, *Postelectrotermes nayari***)

INTRODUCTION

That there are glandular tissues which secrete trail laying pheromones has been confirmed (LÜSCHER & MÜLLER, 1960; STUART, 1961). Sternal gland which is usually present in the fifth abdominal sternite of termites lay odour-trail of value in alarm behaviour and nest construction (STUART, 1967; MOORE, 1974; HOWARD *et al.*, 1976; RITTER & PERSOONS, 1977). The trail laying pheromone produced by the sternal gland also helps the termites to find their nest-mates or food source. In some species, the sternal gland in winged forms may be involved in sex-attraction (WALL, 1971; PASTEELS, 1972).

Sternal gland occurs in all species of termites and exhibits variation in morphology and glandular products, depending on the life-stage of the animal (ERNST & TOLEDO, 1975). The sternal gland and the mechanism of trail laying have been studied in different species by several workers (STUART, 1963, 1964, 1970; NOIROT, 1969; NOIROT & QUENNEDEY, 1974; MOSCONI-BERNARDINI & VEECHI, 1964; SMYTHEE & COPPEL, 1966; PASTEELS, 1965; MERTINS *et al.* 1971; QUENNEDEY, 1971, 1972, 1975; RITTER *et al.*, 1977). Despite the information on various aspects of sternal gland, there is much to be known about these organs which produce chemical signals or pheromones. It is also likely that the same gland may produce more than one pheromone. Here an attempt has been made to elucidate the glandular details and the mechanism of trail laying in the termite, *Postelectrotermes nayari* ROONWAL & VERMA, 1971.

MATERIAL AND METHODS

P. nayari were collected from field and reared in small laboratory colonies. They were fed pieces of wood and occasionally watered to maintain humidity. Animals of various stages of growth, and different castes were used for the study. They were dissected in insect Ringer and the fifth abdominal.

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sternite together with the adjoining sternites i.e., fourth and sixth, were cut and fixed in Bouin's fluid. The tissues were processed in the routine manner and sections were cut at 8μ. They were stained with haematoxylin–eosin for histological studies as outlined by PEARSE (1968). For histochemical studies, the tissues were fixed either in 10% formalin or in Carnoy's fluid. Fat was studied by Baker's Sudan Black B method with acetone treated controls; Glycogen by PAS technique of MC MANUS with control sections tread with saliva and protein by mercury brom-phenol blue method of BONHAG. The extract of different parts of the body of the adult workers of pseudergates and an extract of the host wood *Pterocarpus marsupium*, were prepared and tested for trail-following activity. Ether was used for extracting the active substance. Extracts of head region, tergites 4–6, tergites 8–10 and gut contents of 25 animals each were prepared for testing trail-following activity. The extract was streaked on a clean Petridish and observed for trail-following activity. A total of 30 animals were used for testing the effects of various extracts. A particular extract was considered to have elicited trail-following activity only if termites were found following the artificial trail. Pseudergates which were drawn to the extract upon introduction, but not found following were put in the attractants group. Ether alone was used in the control. Animals that responded to various extracts during a 5 minute observation was recorded.

RESULTS

The sternal gland is present in all castes of *P. nayari* and is highly developed in pseudergates (Fig. 1). In reproductive forms and in nymphs (Fig. 2) the gland is regressed. The gland is seen as an epidermal thickening on the fifth abdominal sternite, below the fourth abdominal ganglion (Fig.3). It is covered externally by the cuticle.

The gland is crescent shaped and has two distinct regions—the gland proper which is the anterior portion and the tapering posterior portion. The total length of the gland of a 7mm pseudergate is about 300μ. The anterior region has a length of about 165μ and the posterior region about 135μ.

The anterior portion of the gland consists of two types of cells (Fig. 4). A row of columnar, vacuolated cells are seen on the anterior portion of the gland near the cuticle. Below this are a number of darkly stained nuclei, with indistinct cell boundaries. From the darkly stained nuclei a number of elongated cell processes run towards the cuticle. Longitudinal sections have shown the occurrence of multiple rows of these structures. These are companiform sensillae and they terminate below the cuticle. The narrow posterior portion of the gland extends beneath the cuticle towards the sixth segment (Fig. 5). This region possesses a number of densely packed nuclei. No duct opening to the outside could be found.

Histochemical studies of the gland indicate the presence of fat in the anterior region of the gland (Fig. 6) which appears vacuolated in histological preparations. Protein and glycogen have been comparatively less in the gland.

There is difference in size of the gland in various nstars of *P. nayari*. The gland attains maximum development in pseudergates which are very active and do much excavation, whereas in larvae the gland is very much regressed.

P. nayari usually does not engage in foraging activities. The tunnels in the wood in which they inhabit serve as source of food and pathway to move about. Occasionally, while making searching movements, some of them go out of the track or tunnels. Otherwise, they are seen following each other within the tunnels.

When a normal colony of *P. nayari* is disturbed, the frightend nestmates run hurriedly into the interior of the nest through tunnels in the wood. While doing so it is observed that the abdomen is dragged close to the substratum. At other times,

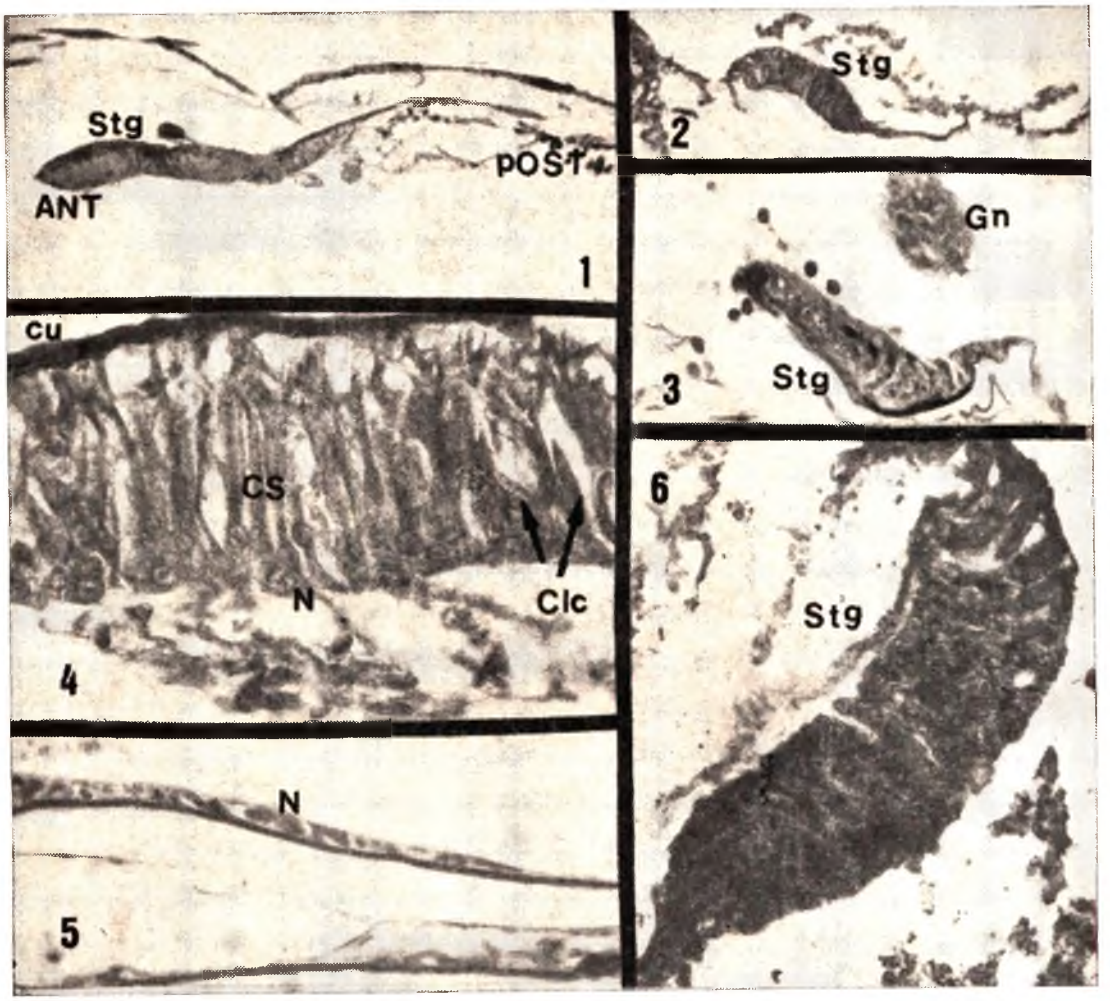

Fig. 1. Sagittal section (S.S.) of the sternal gland of pseudergate of *P. nayari*, × 100; Fig. 2. S.S. of the sternal gland of nymph of *P. nayari*, × 100; Fig. 3. Sagittal section, showing the position of the sternal gland below the abdominal ganglion, × 100; Fig. 4. S.S. of the sternal gland of pseudergate of *P. nayari* showing glandular details; Fig. 5. S. S. of the sternal gland of pseudergate of *P. nayari* showing the posterior region, × 400; Fig. 6. S. S. of the sternal gland of pseudergate of *P. nayari* showing the distribution of fat, × 400.

ANT – anterior; Clc – Columnar vacuolated cells; CS – Companiform sensillae; CU – Cuticle; Gn – 4th abdominal ganglion; N–nucleus; Stg–sternal gland;

TABLE 1. The proportions of trail-following, feeding and attraction of *P. nayari* in response to various extracts.

Body region/wood extract in ether	Termite response (Proportion)		
	Trail following	Feeding	Attraction
Head region	0	0	0.13
Tergites 4–6	0.53	0	0.33
Tergites 8–10	0	0	0.27
Gut contents	0	0.17	0.40
Wood extract	0	0.40	0.60
Control	0	0	0

while moving, the abdomen does not touch the ground. Frequent to-and-fro jerking movements have been observed among the nestmates. When one member of the colony starts this characteristic pattern of movement, it induces the adjacent one to behave the same way. The excited nest mates never fail to follow the one in front.

It is noted that pseudergates of *P. nayari* readily follow an artificial trail of the 4–6 abdominal sternites of the species, when streaked on a clean Petridish (Table I). The extract of the abdominal sternites 8–10 or the gut contents were ineffective in eliciting trail-following behaviour. However, some pseudergates are found to cluster around the extract of the gut contents, mainly feeding on it. The same response is shown to the extract of the host wood too. The comparatively larger number of pseudergates that is drawn towards the wood extract indicate that it contains some attractive substance. However, pseudergates are not found following the artificial trail of the extract of the host wood. It is also observed that invariably all the extracts tested are attractive to pseudergates, except the control. All the nonzero proportions given in the table are found to be statistically significant.

DISCUSSION

The sternal gland is found in all species of temites, performing a common function in all, but its exact location in the abdominal sternite, varies in different species (NOIROT & THIMOTHEE, 1965). In *P. nayari* which belongs to the family Kalotermitidae, the sternal gland is located on the fifth abdominal sternite. LÜSCHER & MÜLLER (1960) and later STUART (1961) independently came to the conclusion that primitive termites also lay an odour trail. STUART (1969) confirms that termites are indeed guided by odour trail and the pheromone is produced from the sternal gland of the abdomen.

The location and overall histological details of the sternal gland of *P. nayari* are similar to those found in *Reticulitermes flavipes* (SMYTHEE & COPPEL, 1966) and *Coptotermes formosanus* (MERTINS *et al.*, 1971). The two types of cells seen in the gland proper of *P. nayari* are described in the above termites also. However, the large elongated

oval lumen in the central portion of the sternal gland of *C. formosanus* hs not been found in *P. nayari*. In *R. lucifugus* (MOSCONI-BERNARDINI & VEECHI, 1964) there occur small epithelial cells forming evacuation tubules, but they have not mentioned about the companiform sensillae. SMYTHEE & COPPEL (1966) have detected cuticular domes in the gland of *Reticulitermes* which they suspect to be companiform sensillae. The presence of campaniform sensillae in the sternal gland of *P. nayari* confirms the observations in *Kalotermes* (NOIROT & THIMOTHEE, 1965). Though the layered arrangement of cells within the gland is lacking, the sternal gland of *Zootermopsis* possesses a large number of companiform sensillae (STUART, 1964). STUART & SATIR (1968) suggest that the production of trail-laying pheromone may be under an elaborate feedback control mediated through the campaniform sensillae.

As with other studies on the sternal gland, no duct opening to the outside has been found in *P. nayari* also. It is quite likely that when the abdomen is pressed against the ground, the trail-laying pheromone may pass through the cuticle. STUART & SATIR (1968) reports the presence of a reservoir, formed due to the overlapping of the fourth abdominal sternite over the fifth one. STUART (1970) also indicates that this reservior may act as a storage place and the campaniform sensillae would then play a role in the transfer of information due to the compression of sternites, as and when required. Thus it is reasonable to assume that termites have some control over the laying of pheromone according to its needs. LEUTHOLD & LÜSCHER (1975) state that the size of sternal gland is not directly correlated with pheromone activity.

The histochemical observations of the sternal gland in *P. nayari* shows the presence of lipid in abundance and so the secretion from the gland would be either lipid or a lipid-soluble substance. Earlier studies also indicate that the trail-laying pheromone in termite is a lipid-soluble substance (STUART, 1969; QUENNEDEY, 1971)

An increase in locomotion due to mechanical disturbances or foreign odour is also associated with increased production of trail-laying pheromone. It should be mentioned that the trail laid by a termite is certainly reinforced by the trails of other individuals in the colony by adding their own streaks. Since *P. nayari* make distinct tunnels within the wood, they do not experience much difficulty in following each other. The mechanical contact of the nestmates as a result of some disturbance may be one of the factors that elicits alarm reaction and laying of trail in *P. nayari*. STUART (1967) has shown that primitive termites lay trails in response to such events as repair of nest, breach in the nest etc., which evoke alarm to the colony mates. So it is likely that in *P. nayari* also both alarm and trail-laying phenomena are interrelated.

Although normal trail-following activity is elicited only through natural trail-pheromone from the termite, it is evident from the experiments that termites may orientate and respond to artificial trails also. In the present study, though only the extract of the abdominal tergites 4–6 elicit trail-following activity, pseudergates are attracted invariably to all the different extracts. This indicates that the nest material and the different body parts may contain compounds that are attractive to termites. AMBURGEY & SMYTHE (1977) have shown in *R. flavipes* that both trail-following and arrestant activities are present in extracts of decayed wood, mycelium removed from decaying wood, fruiting body tissue and mycelium grown on synthetic media.

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OENOCYTES AND THEIR FATE DURING THE POST-EMBRYONIC STAGES OF *EPILACHNA VIGINTIOCTOPUNCTATA* FABR. (COLEOPTERA : COCCINELLIDAE)

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There are two generations of oenocytes in *Epilachna vigintioctopunctata* FABR., viz., the large larvel oenocytes and small imaginal oenocytes, both in the vicinity of thoracic and abdominal spiracles but also found scattered among the fat cells. They also appear in the fourth instar lying below the hypodermal layer. The larval oenocytes are lost during the pupal period. The imaginal oenocytes arise from the segmentally arranged groups of hypodermal cells and appear in the prepupa near the vicinity of spiracles.

(*Key words :* **oenocytes, larva, pupa and imago,** *Epilachna*)

INTRODUCTION

Very few workers have succeeded in recording the metamorphic changes occurring in the oenocytes of Coleoptera. They are KREUSCHER (1922), ALBRO (1930), MURRAY & TIEGS (1935) and PAJNI (1968) in *Dytiscus marginalis*, *Galerucella nymphaeae*, *Calandra oryzae* and *Callosobruchus maculatus* respectively. The present paper includes some observations on the oenocytes and their fate during the post-embryonic stages of *Epilachna vigintiocotpuncata*.

MATERIAL AND METHODS

The adult beetles were reared in the laboratory at a temperature of 29±2°C and relative humidity, 75–80 per cent. Twenty specimens of each larval stage were fixed in Carl's fixative. Sections were cut at 6–8μ. Staining was done with Heidenhain's haematoxylin and alcoholic eosin as a counter-stain. Diagrams were drawn with the help of camera lucida.

OBSERVATIONS

Oenocytes are ectodermal structures appearing as large cells with varying shapes and are found irregularly scattered among the fat cells. Most of the oenocytes are found below the hypodermal layer in the vicinity of the thoracic and the abdominal spiracles. The oenocytes can be loosely divided into two major types, as foilows:

Larval oenocytes

In the first larval instar of *Epilachna vigintioctopunctata* FABR. the oenocytes (Fig. 1) are large, oval or spherical structures, each having a distinct, more or less circular nucleus full of chromatin. The cytoplasm is homogeneous, finely granular and eosinophilic. The oenocytes lie mostly below the hypodermal layer clustered in the vicinity of the thoracic and the abdominal spiracles, from where they migrate inward and become embedded in the fat cells. The size of the oenocyte varies in different locations. Those associated with the fat cells measure 0.03 mm in diameter on an average and are large and oval and are designated as type I, while others found scattered in the neighbourhood of the spiracles and trachea measure 0.05 mm in diameter on an average

PLATE 1

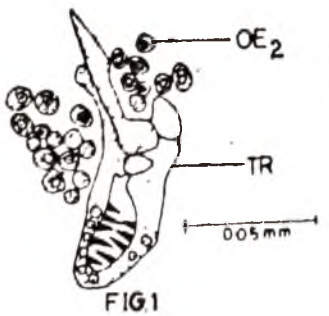
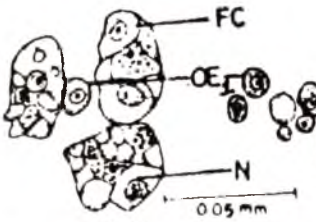


FIG. 1



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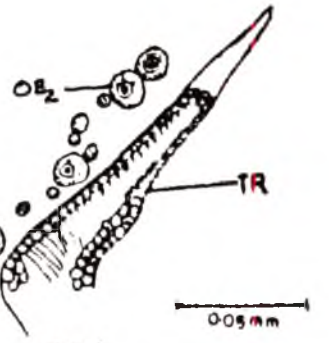

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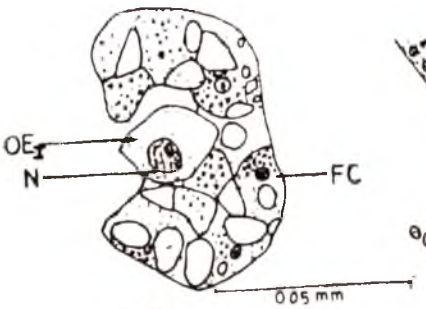

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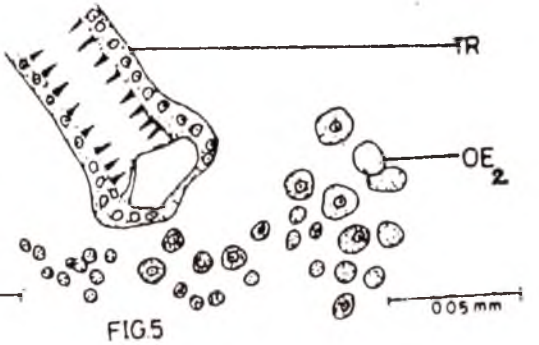

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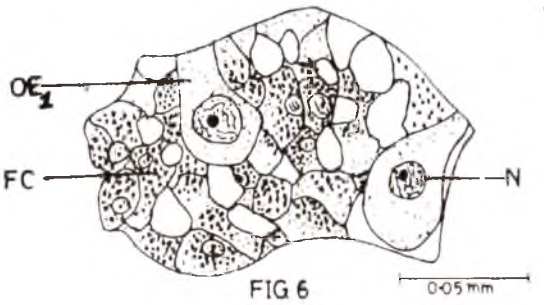

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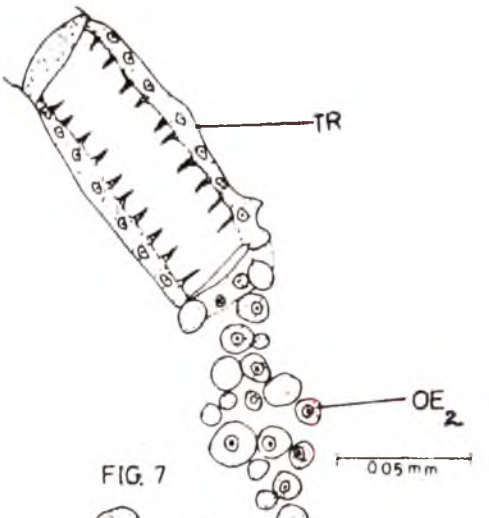

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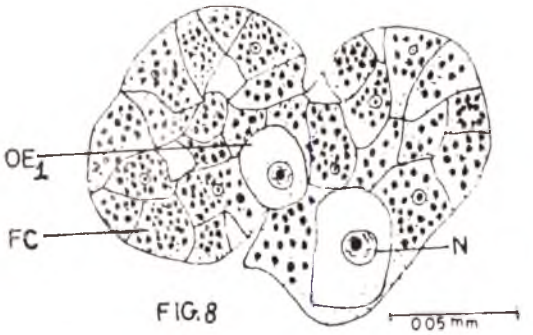


FIG. 8

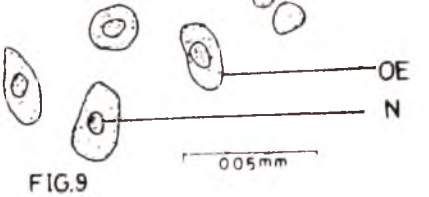


FIG. 9

and are rounded with a centrally placed small nucleus in each and are labelled as type II.

The oenocytes of types I and II (Fig. 3) in second larval instar only increase in size (0.04 mm in case of type I; 0.06 mm in case of type II) and numbers. A number of type II (Fig. 4) migrate into the interior and become associated with the fat cells. The increase in number takes place due to simple differentiation of the hypodermal cells. Except for this, there is no other essential difference.

As the second instar larva moults into the third, both types of the oenocytes (Figs. 5,6) further increase in number, grow in size varying from 0.04mm to 0.1mm in diameter respecively. The oenocytes of type I remain oval; each has a centrally placed distinct nucleus and cytoplasm is finely granular and eosinophilic in contrast to those of type II which are still rounded.

The number of the oenocytes is the greatest in the fourth larval instar (Figs. 7,8). Most of the thoracic and abdominal oenocytes of type I are seen differentiated below the hypodermal layer. These oenocytes also lie below the hypodermal layer in the head region (Photomicrograph 1). Each has a diameter of 0.05 mm (type I) and 0.11 mm in case of type II on an average. The structural details remain the same as described in other larval instars. The oenocytes themselves have not been observed to undergo any division during the larval period.

Fate of larval oenocytes

In the prepupa both the types of the larval oenocytes degenerate and become considerably reduced in size. Subsequently, they lose their individual cytoplasm, the nuclear membrane in each disintegrates leaving the chromatin material barely free. In the early pupal phase, only a few larval oenocytes (Photomicrograph 2) are found scattered among the fat cells. These oenocytes disintegrate and disappear completely in the late pupal period (Photomicrograph 3).

Imaginal oenocytes

The imaginal oenocytes (Photomicrograph, 4) for the first time, appear as segmentally arranged groups of special hypodermal cells placed closer to the thoracic and the abdominal spiracles. Each segmental group of cells consists of 6-9 comparatively small oenocytes. The cytoplasm is densely oesinophilic. The oval nucleus is not as clear as in the larval oenocytes.

In the newly emerged imago, the oenocytes arise as streams from the segmental groups of hypodermal cells, and retain their typical small size. In the older adult, they are found scattered among the fat cells (Fig. 9, and Photomicrograph 5).

DISCUSSION

In Coleoptera, opinions differ as to the apparent arrangement of the oenocytes in close association with the spiracles.

Fig. 1. Oenocytes near the thoracic spiracle and trachea of first instar; Fig. 2. Oenocytes associated with fat cells (first instar); Fig. 3. Oenocytes near the thoracic trachea (second instar); 4. Oenocytes associated with fat cells (third instar); 5. Oenocytes near an abdominal spiracle (third instar); Fig. 6. Oenocytes associated with the fat cells (third instar); Fig. 7. Oenocytes near a trachea (fourth instar); Fig. 8. Oenocytes associated with fat cells (fourth instar); Fig. 9. Oenocytes of an adult (All figures are from transverse sections).

According to KREMER (1925), ALBRO (1930), MURRAY & TIEGS (1935) and PAJNI 1968, they are haphazardly scattered in the neighbourhood of the spiracles. Similar type of arrangements of the oenocytes has been recorded in the larval and pupal stage of *Epilachna vigintioctopunctata* and resembles in all respects with those described for the larva and adults of *Calandra oryzae* (MURRAY & TIEGS, 1935) and *Callosobruchus maculatus* (Pajni 1968).

KREUSCHER (1922), ROTH (1942) and WIGGLESWORTH (1948) claim that they are arranged in grape like clusters of cells lying adjacent to the lateral longitudinal trunks of the larva and the adult.

The third type of arrangement is described by KORSCHELT (1924) and EIDT (1958). According to them the oenocytes generally occur in the form of a broad band, one cell thick, which lies between the fat body and the ventral longitudinal muscles. According to them the lobes of the oenocyte mass pass laterad and ventrad to the vicinity of the spiracles and are intimately assoiated with the trachea and the lateral muscles.

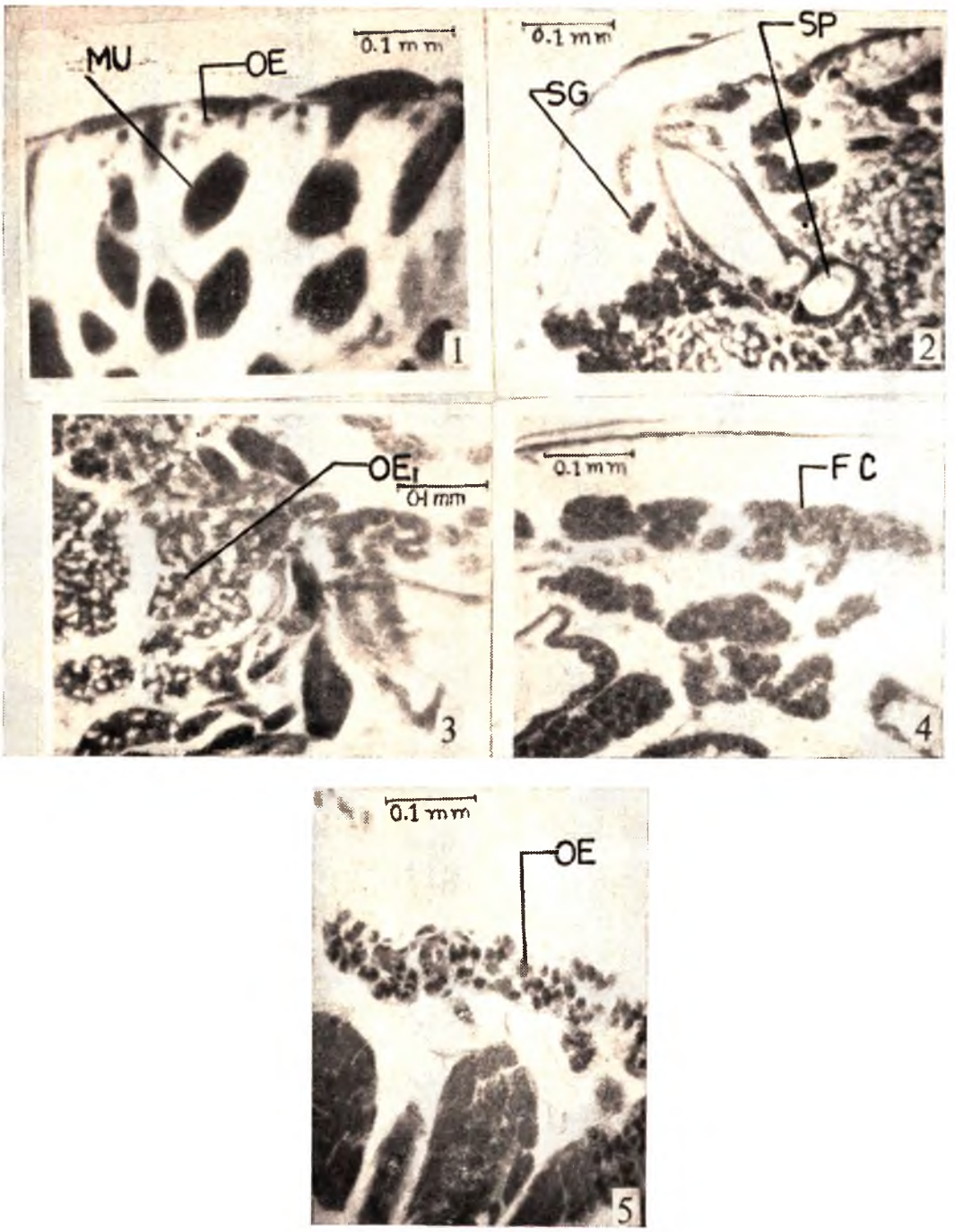
WHEELER (1892) while reviewing the work on the oenocytes, claimed that they generally originated in the embryo from the segmentally arranged groups of cells near the spiracles and constituted a primitive condition which is maintained in the adults of Ephemeroptera, Odonata, Plecoptera and Isoptera.

Regarding the distribution, the oenocytes are found in the thorax as well as in the abdomen of *Epilachna vigintioctopunctata*. The observations agree with those of WEISSENBERG (1906), NELSON (1924) and ALBRO (1930).

As to their origin, the imaginal oenocytes represent derivatives from the segmental groups of hypodermal cells in the thorax and abdomen, occurring in almost all the reported coleopterous spcecies (KREUSCHER, 1922; MURRAY & TIEGS, 1935; PAJNI, 1968). PAJNI (1968) describes their differentiation from the hypodermal layer in the head region of *Callosobruchus* sp. The same holds true in *Epilachna vigintioctopunctata*.

A number of different kinds of inclusions have been described to occur in the cytoplasm of the oenocytes in Coleoptera and other insects. These include the presence of spindle shaped clefts in *Ephestia* (STENDELL, 1912) and *Dytiscus* (KREUSCHER, 1922), or crystalline bodies in *Rhodnius* (WIGGLESWORTH, 1933), of peripheral vacuoles in *Galerucella* (ALBRO, 1930) and *Calandra oryzae* (MURRAY & TIEGS, 1935), of rod like structures and brownish granulaes in *Tribolium* (KOCH, 1940) and *Tenebrio* (ROTH, 1942) and of refractile spheres and amber coloured spheres in *Periplaneta americana* (KRAMER & WIGGLESWORTH, 1950). The presence of such inclusions in the cytoplasm of the oenocytes is probably claimed to influence their secretary activity relating to the deposition of the layer of epicuticle and cuticular waxes (WIGGLESWORTH, 1933, 1947, 1948; KRAMER & WIGGLESWORTH, 1950; BERNARD *et al*, 1967). The cytoplasm of the oenocytes in all the post-embryonic stages of *Epilachna vigintioctopunctata* happens to be homogeneous. The special inclusions of any type are lacking. The obeservations agree in details with those given by PAJNI (1968) in *Callosobruchus maculatus*.

In most of the beetles and other holometabolous insects there is only one generation throughout the larval life known as the larval oenocytes. A second generation arises in prepupa or pupa known as the imaginal oenocytes. In *Epilachna vigintioctopunctata*, the larval oenocytes (type I



Photomicrographs : 1. A portion of frontal section of head (Fourth instar), showing oenocytes below the hypodermal layer; 2. A portion of transverse section (prepupa) showing segmental group of oenocytes near the vicinity of abdominal spiracle; 3. A portion of transverse section (early pupa) showing few larval oenocytes; 4. A portion of transverse section (late pupa) showing total absence of larval oenoycytes; 5. A portion of transverse section (adult) showing oenocytes associated with fat cells.

FC – Fat Cell; MU – Muscles; N – Nucleus; OE – Oenocytes; OE1 – Oenocytes associated with fat cells; OE2 – Oenocytes associated with spiracles and trachea; SG – Segmental group of hypodermal cells; SP – Spiracle; TR – Trachea; TS – Transverse section.

and type III distintegrate completely and are lost during the pupal period. They are then replaced by the appearance of the imaginal oenocytes arising from the segmental groups of hypodermal cells in close vicinity of the spiracles. This condition has been reported in *Calandra oryazae* (MURRAY & TIEGS, 1935) and *Callosobruchus maculatus* (PAJNI, 1968) excepting that in *Calandra oryzae*, some of the larval oenocytes fail to disintegrate and co-exist with the imaginal oenocytes in the adult. In *Dytiscus* sp., KREUSCHER (1922) claims that the larval oenocytes do not disintegrate. They only get reduced in size to a certain limit and continue to co-exist with the imaginal oenocytes in pupa and the adult.

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APHIDS (HOMOPTERA : INSECTA) OF DARJEELING DISTRICT AND SIKKIM–ALTITUDINAL DISTRIBUTION, SEASONAL OCCURRENCE AND HOST PLANT RELATIONSHIPS OF APHIDINAE (TRIBES MACROSIPHINI & PTEROCOMMATINI)

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Survey of aphids in the Darjeeling district of West Bengal and Sikkim revealed the existence of 136 species under tribe Macrosiphini and only one species under tribe Pterocommatini of Aphidinae. The occurrence of the number of species varied with the altitude of the locality and also with the season. Maximum number of species could be found between 601m and 1200m and it was much less below and less above this altitudinal range. Irrespective of the altitude of the locality aphid species under Macrosiphini were most abundant during colder months of the year and least during rains. Aphids under both these tribes exhibited substantial host specificity. As much as 36 species of macrosiphine aphids were recorded from 11 plant families belonging to Asteridae and 31 species of aphids from 15 plant families belonging to Rosidae which together form quite a substantial number of 68 plant families recorded as host of this group of aphid. About 42.8% of the macrosiphine aphid species were restricted to only one species of host plant and 81.9% were restricted to only one plant group. The species under Pterocommatini was recorded from the plant belonging to Bucklandiaceae in the localities situated between 601m and 1200m.

(*Key words :* **aphid survey, altitude, season, host plants**)

TRIBE MACROSIPHINI

It has been indicated by GHOSH & RAYCHAUDHURI (1976) that the subfamily Aphidinae includes about 60% of the aphid species found in this region which closely approximates the proportion as given by EASTOP & VAN EMDEN (1973) for the world aphid fauna. The tribe Macrosiphini includes 136 species which are distributed over 58 genera in the region of the present study.

1. *Aphids in relation to altitude of locality and season:*

Abundance of aphid species in localities situated at different altitudinal strata and different seasons vary remarkably (Table 1).

The localities situated between 150m and 600m have much fewer (only 30 species distributed over 18 genera) species of aphid as compared to places at altitudes above 600m. Only one species, *Hyadaphis coriandri* has been found to be typical of this stratum (i.e., the species found only in that stratum). Each of the three strata above 600 m have more than double the number of species as found below 600m, the highest number of species could, however, be found in the highest stratum (1801m to 2400m) of the present study (Table 1). It has further emerged out from the analysis that there exists only 13 species distributed over 9 genera that could be found through all the altitudinal ranges and the species typical to the altitudinal ranges of 601m to 1200m,

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TABLE 1. Occurrence of macrosiphine aphids in different altitudinal strata and months.

Aphid species	Altitudinal strata and months of occurrence			
	150–600 m	601–1200m	1201–1800m	1801–2400m
Acutosiphon obliquoris Basu, Ghosh & Raychaudhuri		XI, XII	I–III, VIII–XII	I–IV, XI, XII
Acyrthosiphon pisum (Harris)		I–IV, XII	I–III	V
Akhaia bengalensis Basu	III–V	I–XII	I–XII	
A. neopolygoni Gh., Gh. & Rch.			IV, XII	I,III
Amphorophora ampulata bengalensis HRL & Basu		I–IV, IX–XII	I,II, IX–XII	I,XII
Amphicercidus indicus HRL & Basu				XII
Arthromyzus smilacifoliae (Ghosh & Rch.)			X	
Aulacorthum dasi Gh., Basu & Rch.				IV
A. magnoliae (E. & K.)		I,VI–XII	VII,XI,XII	IV–VI
A. nipponicum (E. & K.)		III, X–XII		
A. rhamni Gh., Gh. & Rch.			II,V	I,IV
A. solani (Kltb.)		II,XII	XII	I,II
A. (Anaulacorthum) fagopyri Gh. & Rch.				II
Brachycaudus helichrysi (Kltb.)	I–XII	I–XII	I–XII	I–V, XII
Brachymysus jasmini Basu			XII	
Brevicoryne brassicae (Linn.)		I–V,XII	I–V,XII	I–V
Capitophorus eleagni (del Guer.)				VI
C. formosartemisiae (Tak.)	I–V	I–XII	I–VII, IX–XII	I,VI,VII IX,XII
C. himalayensis Gh., Gh & Rch.				I
C. indicus Gh., Gh., & Rch.		I,VI–XII	I–V,XI, XII	I,IV,VII, XI
C. hippophaes javanicus H.R.L.	I–V	I–XII	I,IV,V, VIII,IX XI,XII	III,V,VI

Aphid species	Altitudinal strata and months of occurrence			
	150–600m	601–1200m	1201–1800m	1801–2400m
C. hippophaes mitegoni Eastop				III
C. polygoni Gh., Gh & Rch.				I,II
Cavariella aegopodii (Scop).		IX		
C. araliae Tak.			XII	XII
C. biswasi Gh., Basu & Rch.				III
C. nigra Basu				IV
Cavariella salicicola (Mats).		I–XII		
Coloradoa rufomaculata (Wilson)		XII		
Cryptosiphum artemisiae Buck	I,IV,VIII, XII	I–XII	I–VI,VIII–XII	XII
Dactynotus formosana crepides Gh., Gh. & Rch.	I–IV,XI, XII	II–V		
D. sonchi (Linn.)	II–VII,XII	I–XII	I–VI,X–XII	
D. tenaceti indica Ghosh			I,V	
D. (Uroleucon) lambersi Basu, Gh. & Rch.		IX		
Diphorodon cannabis (Pass.)		VI		
Dysaphis multisetosa Basu		IV		
Eumyzus darjeelingensis Basu & Rch.				IV
Hayhurstia atriplicis (Linn.)		I, IV		
Hillerislambersia darjeelingensis Basu				I,VI
Hyadaphis coriandri (Das)	III,XII			
Hyalomyzus? sensoriatus (Mason)			IV	
Hyperomyzus carduellinus (Theo.)	I–V	I–XII	I–VII,IX–XII	
Impatientinum impatiense (Shinji)		V,XII	VIII	I
Indiaphis crassicornis Basu				I,V,VI,XII
I. rostrata Gh. & Rch.		IV		
Indomyzus sensoriatus Gh., Gh. & Rch.				IV
Jacksonia sikkimensis Basu, Gh. & Rch.				XI
Liasomaphis himalayensis Basu				I–IV,XI
Lipaphis erysimi (Kltb.)	I–VI,XII	I–III,XII	I–IV,XII	I
Macromyzella polypodicola (Tak.)		I–IV,XI,XII	I,II,V	I

Aphid species	Altitudinal strata and months of occurrence			
	150–600m	601–1200m	1201–1800m	1801–2400m
Macromyzus woodwardiae (Tak.)		I–III, VIII–XII	II,III,V, VIII,XI,XII	I,VI,XI
M. (*Anthracosiphoniella*) *maculata* (Basu)		I–V,XI,XII	VI–XII	I,III,VI
Macrosiphoniella grandicauda Tak. & Moritsu		III		
Macrosiphoniella kalimpongensis Basu & Rch.		V,VI,IX		
M. kikungsana Tak.	I,XII	I,II,VI–XII	III,VII–XII	
M. pseudoartemisiae Shinji		II–VI	II,III,V,XII	IV,V
M. sanbornii (Gill.)		I,II,VI–XII	III,V,IX–XII	XI
M. spinipes Basu	X	I–XII	I–III,VIII–XII	
M. yomogifoliae (Shinji)	I,V,XII	I–XII	I,V,VIII, XI,XII	
Macrosiphum aulacorthoides David, Narayanan & Rajasingh		XII	III	
M. pachysiphon H.R.L.			XII	VII
M. rosae (Linn.)	I–VI	I–III,IX–XII	V,XI	III
M. spinotibium Gh., Gh. & Rch.				IV
M. (*Neomacrosiphum*) *pseudoluteum* (Ghosh)				III,XI,XII
M. (*Sitobion*) *akebiae* Shinji	XII	XI		
M.(*S.*) *fagopyri* Gh. & Rch.				I-VI,XII
M. (*S.*) *indicum* Basu		II	III,X–XII	I,IV,XI
Macrosiphum (*S.*) *lambersi* David		IV		
M. (*S.*) *mimosae* Basu, Gh. & Rch.	III			
M. (*S.*) *miscanthi* Tak.	I–III, X–XII	I–XII	I–III,VIII–XII	II,III,XI
M. (*S.*)*plectranthi* Gh., Gh. & Rch.		XII		
M. (*S.*) *rosaeformis* Das	I–V,XII	I–XII	III,V,IX–XII	I,IV
M. (*S.*) *sikkimensis* Gh. & Rch.				I
M. (*S.*) *takahashii* Eastop	III–V, XII	V–XII	I–III,X–XIII	
Masonaphis (*Neomasonaphis*) *anaphelides* Basu			III	III

Aphid species	Altitudinal strata and months of occurrence			
	150–600m	601–1200m	1201–1800m	1800–2400m
Matsumuraja capitophoroides H.R.L.		I	I,XII	I–VI
M. nuditerga H.R.L.				IV–VI
M. urticae Gh., Gh. & Rch.			V	I,XII
Metopolophium? caraganae (Cholod.)		III		
M. malvae Mosley				I,II
M. rubi (Narz.)		IV,V	III,V	I,V
Metopolophium (*Microlophium*) *darjeelingense* Rch., Gh. & Basu				I
M. (*Microlophium*) *rubifoliae* Rch., Gh. & Basu			XII	II,XII
M. (*Neometopolophium*) *davidi* Rch., Gh. & Basu				II–VII
Micromyzus granotiae Gh., Gh. & Rch.	I	I,XI,XII		
M. judenkoi Carver	I–VIII	I,II,V–VIII, X–XII		
M. kalimpongensis Basu		VII–XII		
M. nigrum v.d. Goot.	I,V–XII	I,II,VII–X		
Myzus brevisiphon Basu				VII
M. ceraci (Fab.)		I–III,XII	I,IV,XII	I–V,XII
M. cymballarielus Stroyan			XII	
M. dycei Carver	I,III, X,XII	I–III,X–XII	XI,XII	I,VII
M. filecis Basu				VII
M. letroyi Basu & Rch.		IV		
M. leptotrichus David, Narayanan & Rajasingh		IV–VII		
Myzus maculocorpus Basu & Rch.			I	
M. manoji Basu & Rch.		II		
M. ornatus Laing			I–IV,XI, XII	I–VII,XII
M. persicae (Sulz.)	I–IV,XII	I–III,X–XII	I–V,XI,XII	I–IV
M. ranunculinus (Walk.)			I	

Aphids species	Altitudinal strata and months of occurrence			
	150–600m	601–1200m	1201–1800m	1801–2400m
M. seizesbeckicola Strand		IX		
Neoacyrthosiphon rhododendrii Gh., Gh. & Rch.				I
N. setosum (H.R.L. & Basu)				X
N. taithesienum ovalifoliae Gh., Gh. & Rch.				IV
Neohyalomyzus raoi (H.R.L.)		I,III,VIII	I–V,X–XII	I–VII,XI
Neomegoura cajanae Gh., Gh. & Rch.	I–XII	I–III,V–XII	IX,X	
N. dooarsis Gh. & Rch.		I,VIII		VI
Neomyzus circumflexus (Buck.)		I,II,XI,XII	I,II,XI,XII	
N. dendrobii Basu			V,VI	
N. dicentrae Basu			XI	
N. primulum Gh., Ban., & Rch.				III
Oedisiphum soureni Basu				VII
Paczoskia budhium Ban. Gh. & Rch.			XII	
Pentalonia nigronervosa Coq.	I,V,XII	I–VI,IX–XII	V,VII,IX–XI	
Perillaphis perilliae (Shinji)		III,X–XII	X–XII	
Pleotrichophorus glandulosus (Kltb.)				I
Pseudaphis abyssiniea H.R.L.				VI
Pseudoacyrthosiphon holstii (Tak.)				V,VI
P. takshashii (Ghosh)				V
Shinjia pteridifolia (Shinji)	II	I–V, VIII–XII	I,II,VI, VIII,XI,XII	I–IV,VII, XI,XII
Sinomegoura citricola (v.d.G.)	I–IV,XII	I–XII	IV,V,X–XII	VI
S. photinae (Tak.)			XI,XII	I,VI
S. rhododendri (Tak.)		XII		
Subovatomyzus leucosceptri Basu		I,XII	I,II,XI,XII	I,VII,XII
Taiwanomyzus darjeelingensis Gh., Basu & Rch.				I,II,IV
Tricaudatus polygoni Narz.		VIII	I–IV,IX–XII	I–VI,X
Trichosiphonaphis garberae Gh. & Rch.		II		

Aphid species	Altitudinal strata and months of occurrence			
	150–600m	601–1200m	1201–1800m	1801–2400m
Tuberoaphis hydrangeae digitata H.R.L. & Basu			V	IV,V
Tuberocephalus sasaki (Mats.)		I–IV,VII–XII	II	
Vesciculaphis kalimpongensis Gh., Basu & Rch.		IV		
V. kuwanis Gh., Basu & Rch.			V,XII	
V. pierides Basu			II	III,IV
V. rhododendri Gh. & Rch.			II	
V. verbesci Gh., Basu, Chak. & Rch.	III	III,VIII–XII	I–V VIII–XII	I,VI.
Xenomyzus polygoni (v.d.G.)	I	I,VI,XI, XII	V,XI	
X. scabripes Basu, Gh., & Rch.			I	

1201m to 1800m and 1801m to 2400m are 18 species included in 14 genera, 10 species included in 9 genera and 30 species included in 18 genera respectively but the number of genera typical to those strata are fewer being 5, 3 and 8 respectively. Considering the number of species typical for a particular altitudinal range it appears that stratum of 1801 to 2400m is distinctive because it harbours appreciably high number of typical species. The stratum between 1201m and 1800m appears to be closer in faunal composition with its succeeding stratum than with the preceeding.

The trends of the number and diversity of species of aphid at different altitudinal strata indicate that tropical climatological features found in the lowest stratum exhibit lesser diversity of species and there exists a general tendency of greater diversity of species at higher elevations i.e., in warm subtropical and cold subtropical zones of this area. It is further interesting that the cold subtropical zone of the present study, as per climatological zonation provided by BISWAS (1962), is the bottom fringe area of the temperate zone. This zone (1801m to 2400m) is richest as regards number and diversity of aphid species. The remarks of EASTOP (1973) is corroborated by the present finding that tropical countries are poorly represented by the aphid fauna as compared to temperate countries.

Irrespective of the altitudinal strata the aphid species appear to be more diverse during the cooler months than any other period of year and the monsoon months are not favourable for the aphid as indicated by fewer aphid species found during July-September (Fig. 1.). Some of the species are of irregular occurrence and do not show any seasonal preference and some are found rarely.

The higher concentration of aphid species of this group during winter even at high elevation areas which is a cold subtropical zone may appear somewhat contrasting

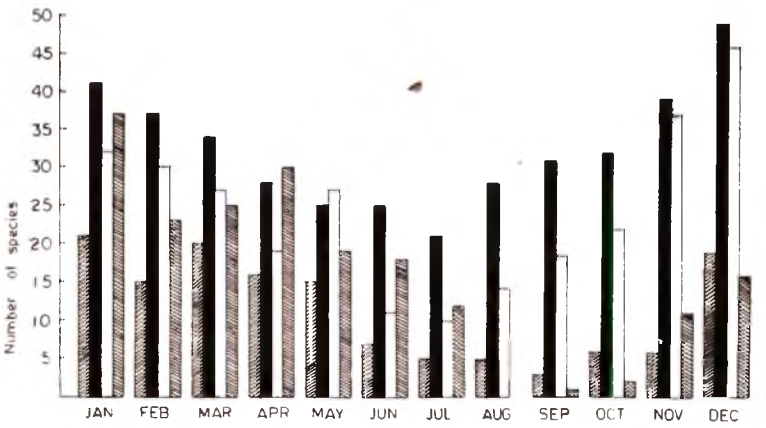

Fig.1 Occurrence of macrosiphine species during different months at stratum between 150–600 m (■), 601–1200 m (■), 1201–1800 m (□) and 1801–2400 m (■).

to the aphid biology as most of them should go into hibernation as egg during this period. But the winter in the area at highest elevation of the present study cannot be ideally compared with that of the temperate countries.

2. *Aphids and host plant relationships:*

136 species of aphids have been found to infest plants belonging to as many 68 families (Table 2) which are included within 8 plant groups. Only plants belonging to Angiosperm and Pteridophyta have been found to serve as host plants of macrosiphine aphids.

The plant groups like Pterydophyta, Magnoliidae, Hammamelidae, Caryophyllidae, Deliniidae, Rosidae, Asteridae and Liliatae harbour 7.9%, 2.9%, 7.9%, 14.5%, 19.6%, 21.7%, 27.3% and 12.3% respectively of the 136 macrosiphine aphid species which are distributed over 15.5%, 6.9%, 10.3%, 7.2%, 9.4%, 31.04%, 36.2% and 17.1% respectively of the 58 genera that could be found to occur in this region through the present studies. However, for quite a few species the identity of the host plants could not be ascertained. It, therefore appears that plant group Magnoliidae harbour least number of aphid genera and species while highest number of these are found on Asteriidae. Relatively higher number of aphid genera and species on pterydophytes is rather interesting when viewed from an angle of evolution of host-plant aphid relationships. Obligate parasitism of aphids on plants may bear some evolutionary relationships with the same of plant groups and there exist quite a few groups of aphids having such relationships (Hille Ris Lambers, 1939) but exceptions are many. The present group of aphids is considered to be the highest evolved and should therefore be associated with highly evolved plants. The association of macrosiphine aphids with Pterydophytes in quite large numbers is, therefore, case of new acquisition as postulated by Eastop (1973).

There are 68 plant families belonging to 8 different plant groups of which Rosidae contain maximum number of plant families that are infested by aphids of this tribe. But the plant group Asteridae which contain next highest number of plant families infested by aphids of this tribe, have the largest number of aphid species infesting them. It is significant, therefore, that concentration of macrosiphine aphid species is

TABLE 2. Aphid and host plant family relationships.

	Number of plant families under								
	Pteridophyta	Magnoliidae	Hamamelidae	Caryophyllidae	Dilleniidae	Rosidae	Asteridae	Liliatae	Total
Infested by one aphid species	2	4	3	2	2	8	2	6	29
Infested by 2–5 aphid species	5	..	..	4	3	5	7	3	27
Infested by 6–10 aphid species	1	..	1	..	3	1	..	1	7
Infested by more than one aphid species	..	..	..	1	1	1	2	..	5
Infested by one aphid genus	1	4	3	2	2	9	2	6	29
Infested by more than one aphid genera	7	..	1	5	7	6	9	4	39
Total number of plant families	8	4	4	7	9	15	11	10	68
Total number of aphid species	10	4	11	20	27	31	39	17	136

much greater on plants belonging to Rosidae and Asteridae. This indicates some relationship of aphid evolution with plant evolution.

It could be found that a substantial percentage of macrosiphine aphids is restricted to a single group of plant (Table 3). The aphid species that are not restricted to one plant group may be termed as highly polyphagous and these form only 18.1% of the 138 species of this group and about 55.8% appears to show appreciable degree of host specificity restricting their feeding on plants of one genus. This is, however, far below the number of aphids in Great Britain that are specific to only one genus (about 90%) as reported by EASTOP (1973). It emerges out from the data that all the 11 species of aphids infesting Pteridophytes are restricted to this group of plant in this region and even all genera excepting *Myzus* are also restricted to this group of plant. None of aphids infesting Angiosperms could be recorded from Pterydophytes. The association with plant at the generic levels of the aphid can also be made out, viz., *Acutosphon* is associated with only *Carex* (Cyperaceae) *Akkaia* with Polygonaceae, *Amphicercidus* with Caprifoliaceae, *Capitophorus* with Polygonaceae and Compositae, *Cavariella* with Salicaceae, *Coloradoa* with Compositae, *Cryptosiphum* with Compositae, *Diphorodon* with Canabaceae, *Matsumuraja* with Urticaceae and Rosaceae, *Hadaphis* with Umbelletae, *Hayhurstia* with Chenopodiaceae, *Indiaphis* with Ericaceae, *Lipaphis* with Cruciferae, *Brevicoryne* with Cruciferae, *Dysaphis* with Rosaceae, *Dactynotus* with Compositae, *Liosomaphis* with Berberidaceae, *Hyperomyzus* with Compositae, *Macrosiphoniella* with Compositae, *Neohyalomyzus* with Rosaceae, *Neomegoura* with Leguminoceae, and *Pentalonia* with Musaceae. The genera that are with only one species and are of infrequent or rare occurrence have not been

TABLE 3. Degrees of host specificity in macrosiphine aphids.

Category of specificity	Number of aphid species	Percentage over total aphid
Aphids restricted to one plant species	59	42.8
Aphids restricted to one plant genus	77	55.8
Aphids restricted to 2–5 plant genera of the same family	74	17.4
Aphids restricted to one plant family	101	73.2
Aphid restricted to one plant group	113	81.9

considered here and if they would have been considered here it could be found as much as 47 genera aphids are restricted to one or upto 2 plant families.

TRIBE PTEROCOMMATINI

The tribe Ptercommatini is represented by only *Pterocomma bicolor* (Oestlund) infesting a plant belonging to Bucklandiaceae related to Talicaceae. The aphid could be recorded in localities between 601m and 1200m during the month of March–April.

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GENITALIA OF *PYGAERA FULGURITA* WALKER AND *P. CUPREATA* BUTLER (LEPIDOPTERA : NOTODONTIDAE)

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External morphology of male and female genitalia of *Pygaera fulgurita* and *P. cupreata* is described. Shape of uncus, socus, harpe and anellus in male and shape and size of signum in the female are characters of taxonomic importance.

(*Key words:* **Female genitalia, *Pygaera fulgurita*, *Pygaera cupreata***)

INTRODUCTION

The larvae of moths of *Pygaera fulgurita* and *P. cupreata* are known as poplar defoliators in India and Pakistan. An allied species *P. anastomosis* has been reported defoliating poplars in Palaearctic region and Pakistan (SINGH & SINGH, 1975). For identification of moths genital characters are of great taxonomic importance. Genitalia of *P. anastomosis* has been described by ARRU (1965) but no information is available on the genitalia of other two species. With a view to filling up this gap in our knowledge, the present study was undertaken. Morphology of genitalia of *P. fulgurita* and *P. cupreata* has been described and comparison made with the genitalia of *P. anastomosis* as given by ARRU (1965).

MATERIALS AND METHODS

Male and female genitalia of *Pygaera* spp. were dissected, dropped in 10% KOH solution, boiled, washed, stained in aqueous acid fuchsin and dehydrated in different grades (30%, 50%, 70%, 90% and absolute) of ethyl alcohol, cleared in clove oil and mounted.

Three main methods of mounting the male genitalia have been used.

(i) "Lateral mounts" in which the genitalia are in a position so that harpe of one side is totally covered by harpe of the other side.

(ii) "End on mounts" with the harpe folded up on either side of the vinculum and the aedeagus flattened between the gnathos.

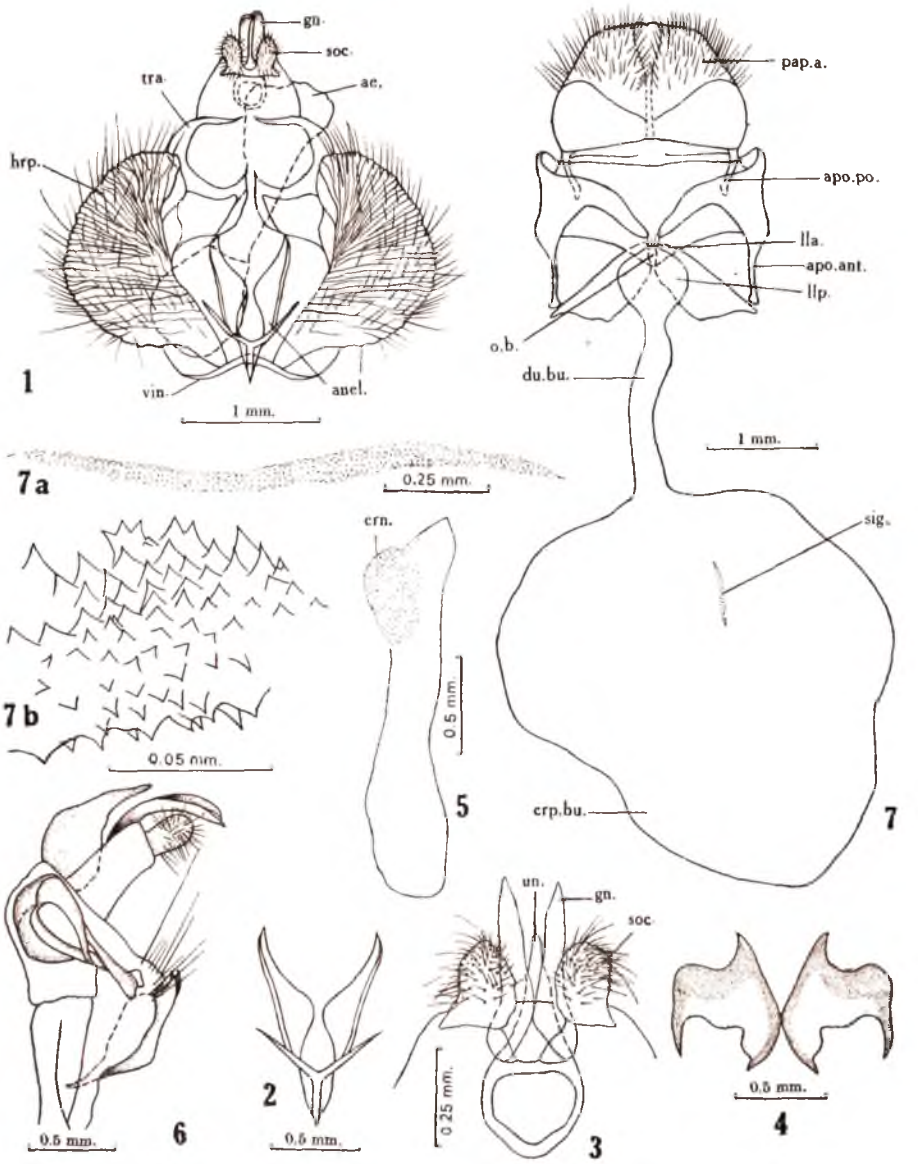
(iii) "Dissected mounts" in which aedeagus, gnathos, transtilla and anellus have been dissected free from the diaphragm and mounted separately from the harpe and vinculum.

Female genitalia of *Pygaera* spp. after normal KOH treatment, washing, staining, dehydration and clearing was mounted ventrally so that Ist (papillae anales) and II (lobulus vaginalis) pair of lobes with ostium bursae, ductus bursae and corpus bursae are visible.

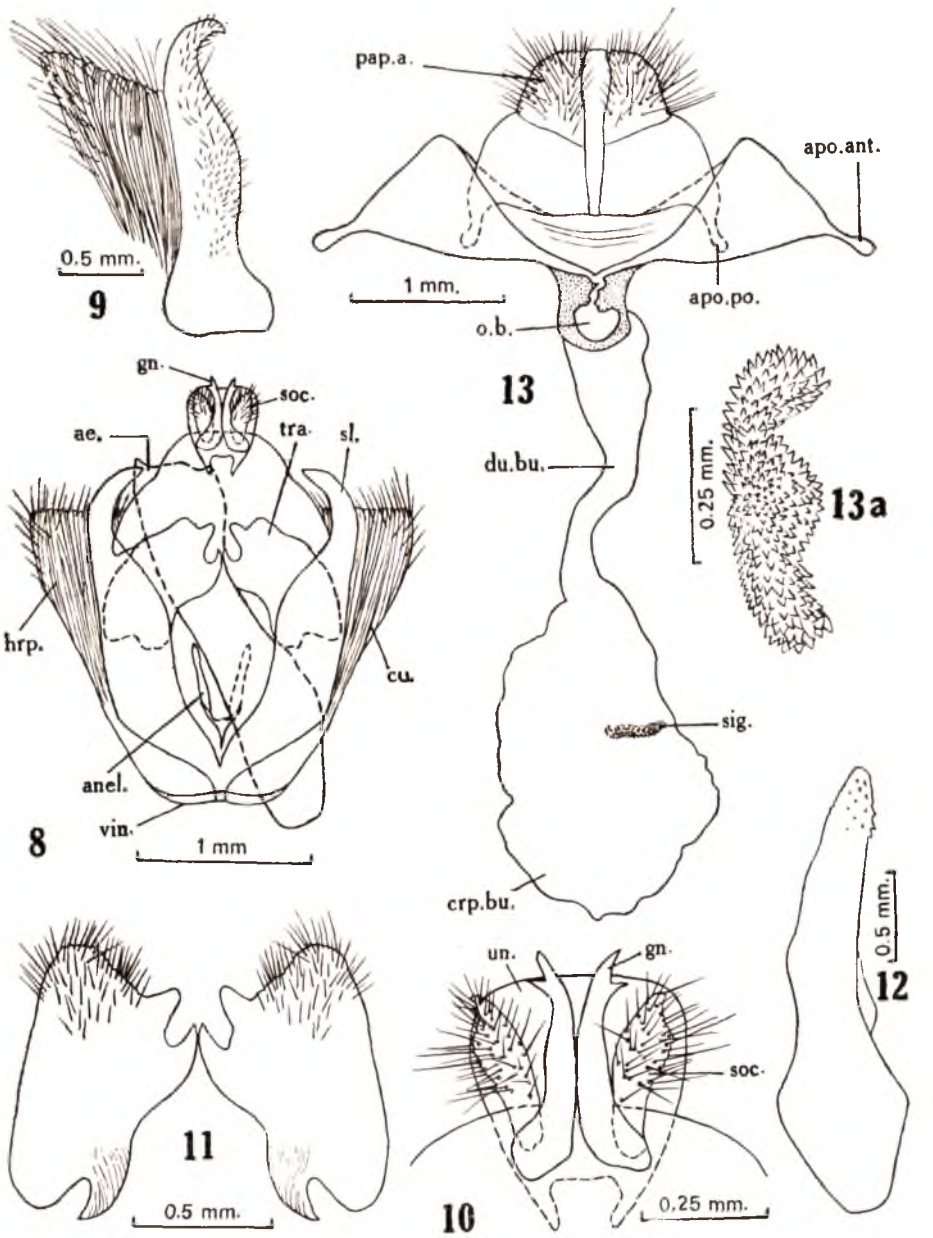
RESULTS AND DISCUSSION

Male genitalia (Figs. 1,8)

The sclerites of the 9th segment, together with parts derived from the 10th, form a transverse ring, the tegumen, which serves as a basis for the attachment of other genital structures. The base of tegumen rests on the plane of the ventral surface of abdomen, the upper part curving posteriorly unitl it lies longitudinally in the plane of dorsal surface. It is flattened sac of thin chitin, enclosed in a stronger ring, the



Figs. 1–7. Genitalia of *Pygaera fulgurita*: 1. Male genitalia; 2. Anellus; 3. Gnathos, socii and unci; 4. Transtilla; 5. Aedeagus; 6. Lateral view of unci, gnathos, socii and transtilla; 7. Female genitalia; 7a. Signum (complete); 7b. Signum (a part enlarged),



Figs. 8–13 Genitalia of *P. cupreata;* 8. Male genitalia; 9. Harpe; 10. Gnathos, socii and unci; 11. Transtilla; 12. Aedeagus; 13 Female genitalia; 13a. Signum.

ABBREVIATIONS

ae., aedeagus; anel., anellus; apo. ant., apophyses anteriores; apo. po., apophyses posteriores; *crn, cornuti*; *crp. bu., corpus bursae*; *cu., cucullus*; *du. bu., ductus bursae*; *gn., gnaths*; hrp., harpe; lla., lamella antevaginalis; llp., lamella postvaginalis; o.b., ostium bursae; pao. a., papillae anales; sig., signum; sl., sacculus; soc., socii; tra., transtilla; un., uncus; ves., vesica; vin., vinculum.

dorsal point of which is called the uncus and the ventral portion the vinculum.

Uncus (Figs. 1,3,6,8,10)

It occupies the central upper part of the tegumen. It is trifurcate in both the species. The side branches of uncus are known as subunci. They have been variously termed as branchia, falces, gnathos. The central hook of uncus varies greatly in all the three species. In *P. fulgurita* it is mandibulate, in *P. cupreata* it is spatulate while in *P. anastomosis* it is simple and in a more or less tube form (ARRU, 1965). The subunci of *P. cupreata,* are bifid at their apical end while in *P. fulgurita* these are mandibulate and pointed at their apical ends. In *P. anastomosis* these are also bifid.

Socus (Figs 1,3,6,8,10).

A paired process called socus arises from the caudal margin of tegumen. These are blunt, soft and densely hairy. The socii of *P. anastomosis* (ARRU 1965) are similar to *P. fulgurita* and *P. cupreata* except they are sinuate at their apical and lateral margins and are not densely hairy. *P. cupreata* and *P. fulgurita* can be distinguished by the presence of smooth lateral and apical margins in *P. fulgurita* and rough in *P. cupreata.*

Aedeagus (Figs. 1,5,8,12)

It consists of a stout tube, with an opening in the side near the base (which receives the seminal duct), and contains the eversible balloon-like membrane, the vesica. This vesica is of most delicate texture and can only be examined when extruded. Extending cephalad into the body vesica meets the caudal end of ductus ejaculatorius along which sepermatozoa come from the paired testes and vasa deferentia. The vesica is eversible from aedeagus. The stout tube of aedeagus near orifice bears cornutes in *P. cupreata* while these cornutes are visible in *P. fulgurita* and *P. anastomosis* on a small part of vesica.

Transtilla (Figs. 1,4,8,11)

It is a stout, paired structure, pointed at its apical end and bears hairs on each half of transtilla medially in *P. cupreata*; in addition to the apical projection, a smaller projection is also visible which unites at its distal end with its partner. Transtilla of *P. anastomosis* is fused in the middle (ARRU, 1965).

Harpe (Figs. 1,8,9)

Below the articulation of the tegumen, are hinged, on either side, the two large wing like processes which form the harpes. In *P. fulgurita,* it is difficult to divide it into its parts, while in *P. cupreata* it is easily distinguished into cucullus and sacculus. Sacculus is peaked. The upper half of harpe in *P. cupreata* and *P. anastomosis* is full of hairs while in *P. fulgurita* hairs are present throughout the harpe.

Female genitalia (Figs. 7,3)

The genitalia are ditrysian type, in which the two reproductive openings, that is ostium bursae of bursa copulatirx and ostium oviductus near anus are widely separated.

Female genitalia consist of the ovipositor, ostium, ductus bursae and bursa copulatrix.

Ovipositor (Figs. 7,13)

It is in a tubular and retractile form. It consists of two pairs of lobes of which most prominent are papsillae anales which are soft and hairy. Ostium oviductus (oviporus) opens in between the papillae anales just caudad or ventral of anus. From cephalo-subdorsal edges of the 8th and the 10th (or united 9th and 10th) tergites extend,

TABLE 1. Measurements of male and female genitalia of *P.fulgurita* and *P.cupreata*.

Name of the parts	*P. cupreata* (mm)						*P. fulgurita* (mm)					
	Male			Female			Male			Female		
	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
a. *Uncus*												
Length	0.50	0.51	0.50	..	..	..	0.49	0.52	0.50	..	..	..
b. *Sub-uncus*												
Length	0.47	0.50	0.48	..	..	..	0.30	0.32	0.30	..	..	..
c. *Socus*												
Length	0.17	0.20	0.18	..	..	..	0.22	0.30	0.25	..	..	..
d. *Aedaegus*												
Length	1.80	2.12	1.95	..	..	..	2.40	2.60	2.50	..	..	..
Width	0.50	0.52	0.50	..	..	..	0.55	0.70	0.64	..	..	..
e. *Harpe*												
Length												
From outer angle of apical end to the base of cucullus		..	..	..	..	..	0.75	0.75	0.75	..	..	..
From inner angle of apical end to the base of cucullus	..	..	..	..	..	..	1.28	1.30	1.29	..	..	..
From apical end to the base of sacculus												
Width	1.47	1.55	1.51	..	..	..	2.02	2.07	2.03	..	..	..
maximum (where both the harpe unite)	1.25	1.32	1.29	..	..	..	1.20	1.37	1.28	..	..	..
Minimum (from apex)	0.52	0.65	0.58	..	..	..	..	..	..	..	..	..
f. *Ovipositer*												
Length		..	..	1.62	1.82	1.71	..	..	..	2.00	2.07	2.04
g. *Ductus bursae*												
Length	.	..	..	1.95	2.07	2.01	..	..	..	1.50	1.62	1.57
h. *Corpus bursae*												
Length	..	..	..	2.27	2.50	2.37	..	..	..	2.12	2.50	2.27
i. *Signum*												
Length	..	..	..	1.25	1.27	1.26	..	..	..	0.37	0.57	0.46
Width	..	..	..	0.05	0.07	0.06	..	..	..	0.12	0.15	0.13

TABLE 2. Length and width of different parts of male and female genitalia (Mean ± S E) of *P. fulgurita* and *P. cupreata*.

Name of the parts	*P. fulgurita*		*P. Cupreata*		Significance
	Male	Female	Male	Female	
a. *Uncus:*					
Length	0.2540 (±0.003)	..	0.2558(±0.006)	..	xxx
b. *Subuncus*					
Length	0.2324(±0.006)	..	0.0933(±0.03)	..	xxx
c. *Socus*					
Length	0.0332(±0.006)	..	0.0652(±0.17)	..	NS
d. *Aedeagus*					
Length	3.8293(±0.17)	..	6.2580(±0.05)	..	xxx
Width	0.2540(±0.001)	..	1.9220(±0.28)	..	xx
e. *Harpe*					
Length	2.2628(±0.05)	..	4.1456(±0.03)	..	xxx
Width	1.6751(±0.32)	..	1.6430(±0.10)	..	NS
f. *Ovipositor*	..	2.9378(±0.21)	..	4.1295(±0.11)	xxx
g. *Ductus bursae*					
Length	..	3.6657(±0.13)	..	2.4617(±0.81)	xxx
h. *Corpus bursae*					
Length	..	5.6526(±0.09)	..	5.3013(±0.09)	xx
i. *Signum*					
Length	..	1.5826(±0.01)	..	0.2148(±0.12)	xxx
Width	..	0.0034(±0.01)	..	0.0176(±0.01)	xx

xx Significant at 1% level

xxx Significant at 0.1% level

NS Not significant

cephalad and inwardly paired sclerotized apodemes functioning for support and muscle attachment. Those of 8th segment are apophyses anteriores and those of 9th and 10th (of which papillae anales are the most prominent structures) are apophyses posteriores.

Ostium bursae (Figs. 7,13)

It is surrounded by chitinized plate known as genital plate. The lamella antevaginalis of this plate is cephalic and ventral of ostium and lamella post vaginalis which is dorsal and caudal of the ostium. These structures are of great taxonomic importance and are not shown in *P. anastomsis* (Arru 1965).

Ductus bursae (Figs 7,13)

Ostium bursae opens into ductus bursae which is bulbous at its base in *P. fulgurita* and straight in *P. cupreata* and opens into bursa copulatrix.

Bursa copulatrix (Figs. 7,13)

The most important feature of armature of bursa copulatrix is signum. Signum is a chitinized plate of great taxonomic importance. Size and shape of this plate varies greatly in the three species. It is sickle shaped in *P. fulgurita* (size, 1.26 mm in length and 0.06mm in width). Saddle shaped in *P. curpreata* (size 0.46 mm in length and 0.13 mm in width) and oval patch in *P. anastemosis* (Arru, 1965). The signum plate has numerous acuminate teeth (spines) which are small and yellowish brown in *P. fulgurita,* camparatively bigger and dark brown in *P. cupreata* and biggest in *P. anastomosis.*

Measurements

Minimum and maximum values and their means for the length and width of different parts of (male and female) five genitalita of both the species are given in Table 1.

Mean $\pm$ standard error values (Table 2) for both the species were taken and length of uncus, subuncus, harpe, aedeagus in male and length of ductus bursae, corpus bursae, signum in female were found highly significant at 0.1% levels. Similarly width of aedeagus in male and signum in female were highly significant. Length of ductus bursae in female was found significant at 1% level while length of socus and width of harpe were not significant.

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BIOLOGY OF *EOEURYSA FLAVOCAPITATA*-A DELPHACID INSECT PEST ON SUGARCANE IN INDIA

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Biology of *Eoeurysa flavocapitata* MUIR (Homoptera: Delphacidae), a recently recorded insect pest of sugarcane crop from West Bengal is studied in specially prepared cages fixed on sugarcane leaves. Mating is found to occur on the leaf-surface any time of the day. Following a pre-oviposition period of 4–7 days oviposition occurs on the leaf, tissues bordering the midrib being the favourite site. Total number of eggs laid by a single female varies from 143–234. Incubation period varies from 8–11 days. There are five nymphal instars and for completion of their development they take 16–24 days. Life-span of the adult male and female is found to vary from 6–10 days and 24–36 days respectively. Also mentioned is the behaviour of nymphs and adults in respect to crop-damage.

(*Key words : Eoeurysa flavocapitata*, **delphacid pest on sugarcane, biology**)

INTRODUCTION

Sugarcane, an important commercial crop, is subject to attack by a host of insects of which Fulgoroidea forms a pre-eminent group. Thus BOX (1953) listed the occurrence of more than 150 species of Fulgoroidea in the world. The occurrence of *Eoeurysa flavocapitata* (Homoptera: Delphacidae) on sugarcane in the northern part of West Bengal, India was first recorded by CHATTERJEE (1971). Prior to him QADRI (1963) and MIRZA & QADRI (1964) recorded this insect from Bangladesh which is adjacement to West Bengal. Recent surveys of sugarcane fields by the present authors reveal that *Eoeurysa flavocapitata* has spread from the agro-ecological barrier of North Bengal to other sugarcane growing areas of West Bengal. In view of growing economic importance of *Eoeurysa flavocapitata* as a pest of sugarcane, studies on the biology of this insect were undertaken

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MATERIALS AND METHODS

The studies on the biology of *Eoeurysa flavocapitata* were carried in insect cages made of nylon mosquito-netting which was wrapped over slotted polythene tubes measuring 15 cm long with 6 cm diameter. Such cage was securely fixed on the second and third young leaves of the sugarcane plant and on freshly emerged adult female with three males of *E. flavocapitata* were released in it. Each cage was examined daily and if egg-slits were noticed, the cage with insects inside was slipped along the leaf and transferred and fixed on a fresh cage. In order to study the fecundity of the ovipositing females, it was necessary to dissect the marked egg-slits.

OBSERVATIONS

Mating and Oviposition: Mating occurs on the leaf any time of the day. The female undergoes a pre-oviposition period of 4 to 7 days. The oviposition occurs in the leaf; the tissues bordering the mid-rib being the favourite site. The tops of the egg clusters

are covered with a waxy material secreted by the females. A characteristic reddish colour develops in the affected tissues around the site of oviposition or "egg slot". The eggs are laid in batches and the number of eggs per slit may vary from 2 to 10. After about 14 days the oviposition stopped in most individuals. The total number of eggs laid by a female over a period of about two weeks may vary from 143 to 234.

The eggs (Fig.1) are elongate—cylindrical, and measure from 0.91 to 1.2 mm × 0.26 to 0.33 mm. The incubation period occupies 8 to 11 days and the insect passes through five nymphal instars to become adult.

Nymphal stages

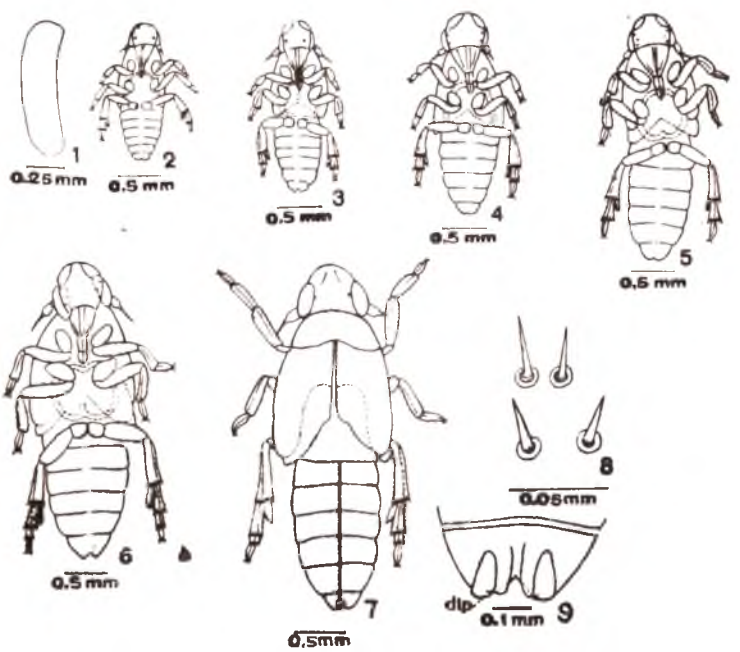
First instar nymph (Fig.2)

Just hatched nymphs are almost sedentary, slender and the colour of the body is dull white. The eyes are reniform, prominent and castaneous. There is a faint median longitudinal carina on the abdominal pleurite and a depressed line on the tergum.

In the head, the vertex occupies the largest area, being longer than broad at base. It is divided by a faintly developed epicranial sulcus, lateral to which are situated the rather bulging eyes. The ocelli are indistinct. The antenna is three-segmented with unequal sized scape and pedicel. The bulbous ring joint fits into the anterior depression of pedicel which projects anteriorly as setaceous flagellum.

The thorax is carinate. The prothorax is broad dorsally and slightly elevated than the pterothorax. The mesothorax is the largest segment. The wing buds do not develop on the notum, and like typical delphacids, the coxa of the metathoracic leg is almost spherical and provided with fine denticles on the inner margin.

In the abdomen, the tergum and the pleurosternite are well discernible but the



Stages in the development of *Eoeurysa flavocapitata*.

laterotergite is rather indistinct. The first and the second abdominal segments are fused and hence only nine segments are apparent. The last abdominal segment which is dark in colour is notched caudally. A apir of processes develop on the dorsolateral hindmargin of the ninth segment and extends through the middle of the tenth segment (Fig.9).

The sensory pits "Borstengruben" (Fig. 8) occur on the body of all nymphal instars. A pit consists of a roundish depression in the cuticle, and a true hair. The hair grows from the basal membrane located in a roundish basal wall at the posterior and slender side of a pit. The pit appears to function as a sense organ for humidity.

The total length of the body varies from 1.22 to 1.35 mm and the maximum breadth at the abdomen varies from 0.38 to 0.43mm (average of 10 nymphs). The duration of the first instar nymph varies from 4 to 6 days.

Second instar nymph (Fig. 3)

The second instar nymph is almost creamy yellow in colour. The end of the rostrum is, however, dark and the tibia and tarsus are cinereous grey in colour. The caudal part of the abdomen is dark. The pro- and mesothroacic legs are darker than the metathoracic one. The thoracic pleura can be demaracated into episternum and epimeron. The rudimentary anterior wing-buds faintly appear as lateral lobes on the mesonotum. The second instar nymph measures 1.93×0.52mm.

The duration of the second instar varies from 3–4 days.

Third instar nymph (Fig. 4)

The basic body colour of the third instar nymph is straw yellow, and the eyes are chocolate brown. The legs in general take more brown colour, particularly the pro- and mesothoracic ones. The meso- and methathoracic wingpads start developing conspicuously. Lateraly the mesothoracic wing pad out-stretches the metathoracic one. On the ninth abdominal segment five apodemal struts are discernible. This stage lasts 2–4 days. The nymphs measure 2.50×0.65mm

Fourth instar nymph (Fig. 5)

The vertex and the frontal region are cinereous brown. A sordid white band marks the clypeo-frontal area and there is a dark semicircular spot in the frons close to the fronto-clypeal sulcus. The rostrum is almost black and the intersegmental lines on the abdomen assume deep suffusion. The tips of the tibial spurs and the calcar turn almost piceous. Each of the pair of processes on the abdominal end is unsegmented, subquadrate and rugose-verranculate on the outer margin. The fourth instar nymph takes 3–4 days for its development and it measures 3.25×0.80mm.

Fifth instar nymph (Figs. 6,7)

The vertex of the fifth instar nymph is fuscous and without the Y–shaped carina on the vertex. The basic colour of the thorax and the abdomen is lemon yellow except for the lateral part of the eighth and ninth abdominal segments which are light black. On the postero-median aspect of the inner side of the trochanter, fine serrations become prominent. The apex of the hindwing descends to the fourth abdominal segment and in the late nymphal stage, tracheation in the wing is discernible. The hair bearing granules in the forewing are conspicuous.

In the abdomen only nine segments are discernible, the last two segments being fused together with a wide notch in the

TABLE 1. Relative length (mean ± SE) of femur and tibia of hindleg of nymphs in mm and number of spines on spur (average of 10 specimens).

Nymphal stage	Femur	Tibia	Spines of spur
First instar	0.19±0.007	0.21±0.007	1
Second instar	0.37±0.011	0.42±0.010	3
Third instar	0.42±0.011	0.48±0.010	8
Fourth instar	0.49±0.014	0.56±0.012	14
Fifth instar	0.56±0.010	0.64±0.011	16

middle of the caudal segment. The weakly developed third valvulae in the female is visible.

The fifth instar nymph takes 4–7 days for transformation into adult and it measures 4.0 × 1.08mm

Nymphal period

The total nymphal period covers 16–24 days.

Life-span

The longevities of the adult male and female vary from 6 to 10 days and 24 to 36 days respectively.

The relative length of femur and tibia of the hindleg of different nymphal instars and the number of spines on the spur are presented in Table 1. It is apparent from Table 1 that the lengths of both femur and tibia increase two times while the nymph transforms from first to second instar but increase in length in subsequent instars is much less.

Behaviour of nymphs and adults and damage

Both the nymphs and adults live concealed within the young leaf sheaths of sugarcane. The population gradually builds up with the vegetative growth of sugarcane and the peak population is noticed in months from September to December. Both the nymphs and adults suck the plant sap. Owing to continuous feeding and oviposition, red streaks develop continuously in and around the injured tissues. The streaks coalesce to form bigger lesions. Extensive drainage of sap devitalises the plant. The excretory product or honey dew secreted by both nymphs and adults attracts black ants. Eventually sooty mould develops on the honey dew, the black coating of which interferes with the photosynthesis and transpiration of the plant.

DISCUSSION

The studies include life-history, measurements of body parts of different nymphal instars and behaviour of a delphacid insect *Eoeurysa flavocapitata* which has been recently recorded as a new pest of sugarcane. The information on the biology of *E. flavocapitata* by MIRZA & QADRI (1964) is extramely meagre. Hence, detailed studies on the biology of allied delphacid insects by other workers need to be considered for an appraisal of the present work.

URBINO (1927) while working on the life-history of *Perkinsiella vastarix* (BREDDIN) in the Philippines noted that the interval

between the emergence of adult female and first oviposition on sugarcane varies from 2 to 15 days and that the incubation period of eggs from 14–17 days. Further, 3–4 days are required for completion of each of the five nymphal stages. In the present study the interval between the emergence of adult female and first oviposition was found to range from 6 to 10 days and the incubation period from 8 to 11 days. The life-histories of two other sugarcane delphacids viz., *Perkinsiella saccharicida* and *Saccharosydne saccharivora* as reported by GUAGLIUMI (1953) and WILLIAMS (1957) from Venezuela and Mauritius respectively also fairly agree with the present observations.

The present work also deals with differential growth pattern of some important morphological features as found in different nymphal instars. Many of these characters were earlier used for taxonomic purpose by FENNAH (1963) in his study on the delphacid species-complex. WILLIAMS (1957), RAATIKAINEN (1967) and METCALFE (1969) took into account certain changes in the morphological characteristics in successive instars of delphacid insects to determine the different stages of insects. Metcalfe (1969) also noted that the differentiation of the forewing buds relative to those of the hindwing and to the thorax is important in each instar. The present study on *E. flavocapitata* while forming a basis for conducting studies on other taxa, can be used with advantage for determination of different instars.

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IMPACT OF MATING ON THE OVIPOSITION PATTERN AND HATCHABILITY IN *ACANTHASPIS PEDESTRIS* STAL. (REDUVIIDAE : ACANTHASPIDINAE)

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Acanthaspis pedestris STAL., **a reduviid of scrub jungle of the Palghat gap, manifests wide range of ecotypic specializations. Significant variations are recorded here on the fecundity rate, longevity and hatchability rate of four categories of reproductively competent females namely, (1) the virgins, (2) the females that mated once, (3) females that mated many times with one male of the same age and (4) the females that mated with different males of different age. The last category of females prove to be reproductively efficient under natural conditions.**

(*Key words : Acanthaspis pedestris*, **reduviid, reproductive biology**)

INTRODUCTION

The nutritional and reproductive adaptations of the reduviids of the scrub jungles of the Palghat gap have reached a high degree of precision and efficiency (AMBROSE & LIVINGSTONE, 1978a; LIVINGSTONE & AMBROSE, 1978a). Their structural diversifications illustrate not only their ecotypic specialization but also their behavioural manifestations (AMBROSE & LIVINGSTONE 1978d).

Acanthaspis pedestris STAL., an apterous, crepuscular, entomosuccivorous reduviid, by its diversification of colour, size, longevity fecundity rate, population dynamics, duration of stadial period, size and shape of the spermatophore capsule etc., has established itself as a very successful acanthaspidine reduviid of the various concealment habitats of the scrub jungle.

The impact of mating and blood meal on the oviposition pattern and hatchability rate of a few species of cimicid bugs was attempted first by LEE (1954) on *Haematosiphon inorodorus* and subsequently by RYCKMAN (1958) and DAVIS (1964, 1965a, 1965b) on *Hesperocimex sonorensis* and *Cimex* sp. respectively. EDWARDS (1966) reported first on a reduviid species (*Zelus exsanguis*) the egg laying behaviour of virgins and mated females, their hatchability rate and longevity and subsequently RABINOVICH (1972) reported a fall in the total number of eggs and hatchability rate in the older females of *Triatoma phyllosoma pallidipennis*. No documented evidence is available on similar investigations on oriental reduviids and therefore the present investigation is found interesting.

MATERIAL AND METHODS

Adults of one particular ecotype (semi-arid zone-Chandrapuram stock) were raised in the lab. from fifth instar nymphs, in plastic containers on a single daily feed on camponotine ants and houseflies. Adults representing four different reproductive status viz. (a) Virgins, (b) Females having mated once with a male of the same age group, (c) Females allowed to live (in pairs) throughout with a single male of the same age group, and (d) Females allowed to live with several males of different ages, were maintained

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individually. The containers were examined at regular intervals and the ejected spermatophore capsules were collected each time and thus the records of the number and frequency of mating were maintained.

Records of the number of batches of eggs and the number of eggs in each batch were carefully maintained and each batch of eggs was allowed to hatch in individual containers, provided with optimum rearing conditions. Hatching percentage of individual batch of eggs was calculated and the longevity of the females under experimentation recorded. Measurements of eggs of all four categories of females were also taken.

RESULTS AND DISCUSSION

Reproduction

The internal organs of reproduction of the female consists of seven telotrophic ovarioles on each side and the very short common oviduct develops on either side a very insignificant and functionally obscure pouch, commonly known as pseudospermatheca (Fig. 1). Similar pouches in *Rhodnius* and *Triatoma* are not considered by GALLIARD (1935) homologous to the spermatheca described in other Heteroptera. A median dorsal gland that opens dorsally into the vagina of these bugs are considered by GALLIARD (1935) as cement glands which was later homologised with true spermathaca (CARAYON, 1954; DAVIS, 1955, 1956; DAVEY, 1965). After having considered similar unpaired structure of several families of reduviids LOUIS & KUMAR (1973) confirmed the status of pseudospermatheca to this structure though CARAYON (1954) coined this term first for a pair of "glands" that opened ventrolaterally into the vagina, similar to those of *A. pedestris*. However, quite contradicting reports on the status of the "spermatheca" of Heteroptera in general have left this issue still open for investigation (BONHAG & WICK, 1953; LIVINGSTONE, 1967; MATSUDA 1976).

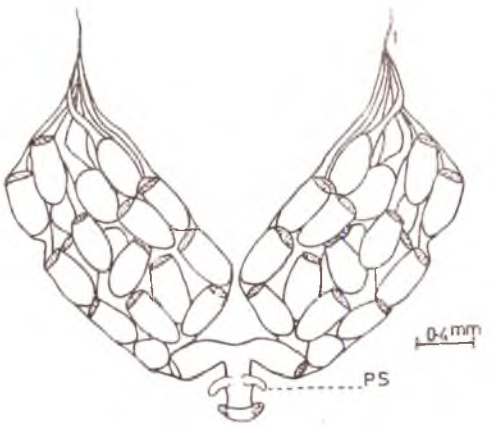

Fig. 1. *A. pedestris*, internal organs of reproduction of a gravid female.

The adult males of *A. pedestris* emerge nearly ten days earlier than the females and the latter become receptive to males only 20–25 days after emergence. Copulation lasts for 20 minutes to 3 hours and the ejection of spermatophore capsule universal phenomenon among reduviids, (indicating successful copulation) takes place at about four hours after each copulation.

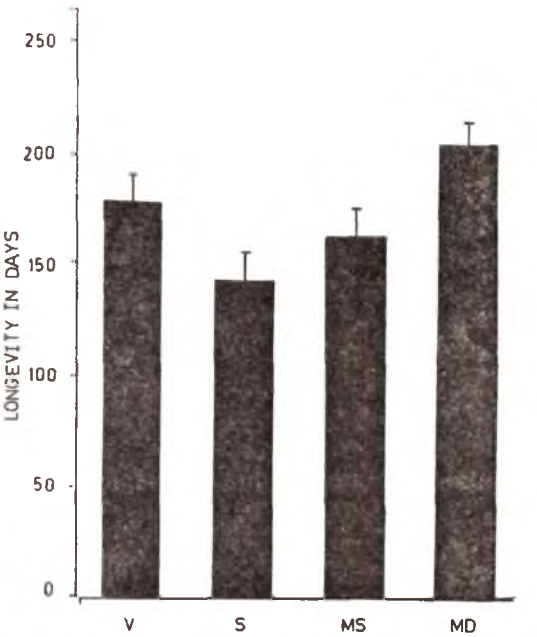

Fig. 2. *A. pedestris*, Longevity (in days) 4 categories of adult females.

A maximum number of eight successful copulations by a female has been so far recorded in the laboratory bred bugs. The first batch of eggs is deposited 34±5.15 days after the first successful copulation and the number of eggs in each batch ranges from 1–16. No particular pattern of egg deposition is followed and no gluing phenomenon is observed. Virgins too oviposit as much as mated ones.

Longevity

The longevity of virgins is apparently higher than that of the females that mated once. But the females that mated with different males register the highest longevity record (Fig. 2 and Table 1). It is also noticed that under identical conditions, the virgins register low fecundity rate, the females that mated once show higher rate of fecundity

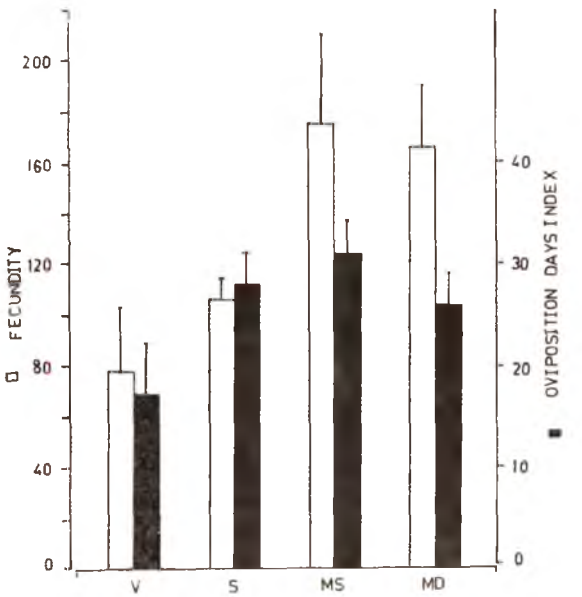

Fig. 3. *A. pedestris* fecundity and oviposition days index.

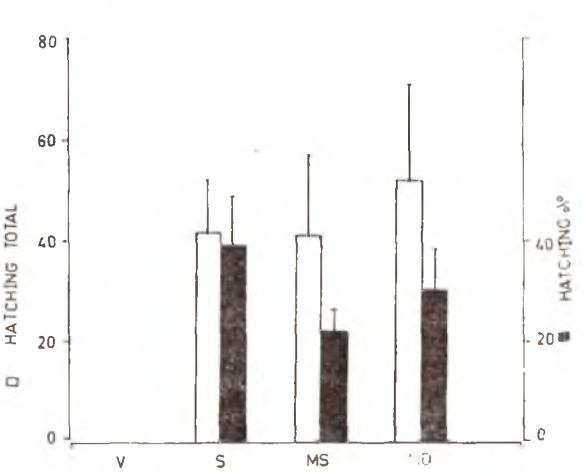

Fig. 4. *A. pedestris*, hatching total and hatching percentage.

and the females that mated more than once with different males record the highest rate of fecundity. It also suggests that the third category (C) of females die earlier due to exhaustion and the fourth category (D) of females live longer than the rest, apparently due to the rejuvenising influence of multiple mating with different males.

Pattern of oviposition

The preoviposition period recorded in all four categories of females is longest (80 days) in the case of virgins that lay lesser number of eggs (78) that are smaller, darker, and shrunken (Fig. 5). In the poultry bug (*Haematosiphon inorodorus*) and in *Hesperocimex sonorensis*, LEE (1954) and RYCKMAN (1958) respectively have reported a total loss of fecundity among virgins. DAVIS (1964) however, has reported in *Cimex* sp. the deposition of not more than two eggs by virgins, after a prolonged preoviposition period.

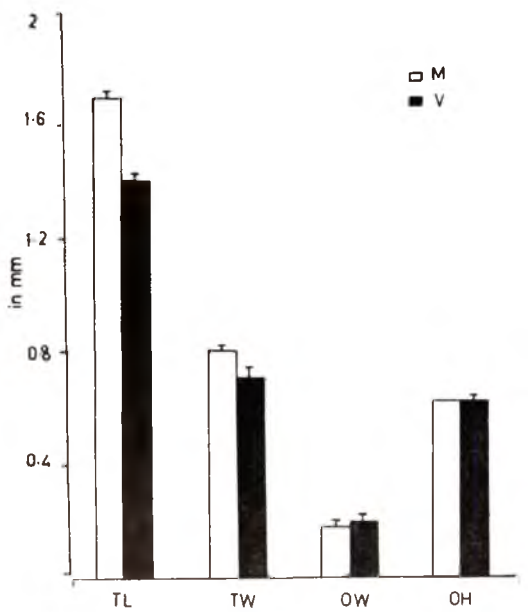

Fig. 5. *A. pedestris*, variation in egg size—Virgins and mated females.

ABBREVIATIONS USED

M – Mated females; MD – Females that mated with different males of different age; MS – Females that mated many times with one male of the same age; OH – Opercular height; OW – Opercular width; PS – Pseudo spermatheca; S – Female that mated once; TL – Total length of egg; TW – Total width of egg; V – Virgins.

An index of oviposition days has been prepared by calculating the percentage of the number of egg laying days during the adult's life span. The highest value is found among females that continued to live together and mated with one male (monandry) of the same age group (Fig. 3). It is significant that more number of eggs in less number of batches has been registered by females that mated only once. In the multiple mating, with different males, though a steep rise in fecundity rate is recorded, the hatchability rate has been found to be considerably diminished (Fig. 4).

Hatchability

Virgin's eggs never hatch. Hatching percentage is not directly proportional to the fecundity rate, as there is a significantly high percentage of hatching in the first category (B) of mated females (Table 1 and Fig. 4). Therefore, it is evident that though multiple mating has direct relaion to high fecundity rate, it does not favour a proportionate hatching rate and yet the highest number of total nymphs hatched out in the case of multiple mating with different males is significant. It is relevant to suggest that the possibility of receiving viable sperms is better ensured in the last category.

As already reported (AMBROSE & LIVINGSTONE, 1978b), under field conditions, these bugs are observed to migrate from one locality to another in search of their natural prey, the camponotine ants. This migratory movement in search of prey provides more opportunities for the females to mate with

TABLE : *Acanthaspis pedestris* : impact of mating on oviposition pattern and hatchability (average of 6 females in each category) ± SE.

		Virgin	Single mating	Multiple mating with a male of same age	Multiple mating with males of different ages
1.	Longevity of adult female in days	176.0±13.86	143.0±12.38	163.4±12.51	204.4±9.75
2.	Age at which first batch of eggs laid in days	69.2±11.89	54.0± 4.01	47.2± 3.6	59.0±8.95
3.	Index of oviposition days	17.5± 5.32	28.4± 3.22	30.72±3.22	26.4±3.2
4.	Total number of batches of eggs laid	32.8±10.67	40.8± 5.49	51.0± 0.1	55.0±7.73
5.	Minimum and maximum number of eggs per batch	1.0±0:8.4±1.89	1.0±0:10.2±1.36	1.0±0:15.8±3.76	1.0±0:10.8±2.24
6.	Average number of eggs per batch	2.18±0.33	2.8± 0.2	3.6± 0.24	3.0± 0
7.	Total number of eggs laid	77.8±24.76	105.8± 8.47	175.0±36.38	166.0±24.14
8.	Total number of nymphs hatched	..	41.6±10.63	41.0±16.24	52.0±18.81
9.	Hatching percentage	..	39.28± 9.84	20.19± 4.38	29.71± 8.12
10.	Age range in which 0% hatching recorded	..	60.6± 5.05 to 127.8± 8.83	47.2± 3.6 to 149.6±19.34	69.2±11.02 to 175.0±19.15
11.	Age range in which 100% hatching recorded	..	57.4± 4.98 to 112.2±10.42	62.0±18.34 to 109.6±33.56	83.8±17.27 to 149.6±11.7
12.	Frequency of 0% hatching recorded	..	17.0± 3.27	27.2± 3.23	31.0± 5.39
13.	Frequency of 100% hatching recorded	..	13.2± 4.6	4.8± 1.98	11.0± 4.51

different males of different localities. This facility is enhanced by the availability of more number of relatively younger males as their longevity is considerably lesser than that of the females. Therefore, this phenomenon serves as an effective measure of maintaining a steady level of natural population of this bug.

Interestingly, the frequency of 0% hatching is recorded high in the two categories (C and D) of multiple mating indicating a fall in the viability of the eggs too. As there is no record of a particular age that marks the production of least viable eggs, it is difficult to establish the physiology of the reproductive status of this insect. On the contrary, the frequency of 100% hatching is more in the multiple mating categories of females (C and D). The single mated category of females (B) with its minimum number of batches of eggs avail the maximum advantage of the stored sperms while the females of multiple mating (C and D), with more number of batches of eggs tend to lose the advantage of multiple mating due to their high fecundity rate and consequently decreased fertility rate.

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EFFECT OF FOOD QUALITY AND RATE OF CONVERSION ON THE GROWTH OF *SPHAERODEMA ANNULATUM* FABR. FED WITH LARVAE OF *CULEX*

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Quantitative analyses of food utilization in *S. annulatum* by providing larvae of *Culex* mosquito as food are made. The third nymphal instar shows potential conversion efficiency than the first instar and that the conversion efficiency is mintained in subsequent instars. The rate of conversion is the highest in the second istar. The significant increase in the morphometry of the third nymphal instar from that of the second instar is reflected in the conversion efficiency and the rate of conversion of food in that stage. The duration of each nymphal instar of *S. annulatum* fed with mosquito larvae in the laboratory conditions is higher than that of the nymphal instars of *S. annulatum* fed with other insects under identical conditions.

(*Key words : Sphaerodema annulatum*, **food quality, conversion efficiency**)

INTRODUCTION

Sphaerodema annulatum FABR. is an aquatic hemipteran which is a voracious feeder and is predaceous on small aquatic insects, tadpoles, small fishes and larvae of dipterans (PRESSWALA & GEORGE, 1936; RAO, 1962). Under prolonged period of starvation, the nymphs are cannibalistic and cannibalism is reported to be predominant in the first two nymphal instars. During the course of an investigation of the biology of *S. annulatum* F., it was noted that the growth rate pattern of natural population differed significantly from that of the experimental population fed only with the larvae of *Culex* mosquito. The above finding suggests that the quality of food consumed could influence the growth pattern of the animal. The conversion efficiency may also differ with different types of food consumed (MADHAVAN & BHASKARAN, 1975). If the conversion efficieny of insects were to differ depending on the type of food, it would be of interest to know whether it is reflected in the growth pattern. In the present study, an attempt has been made to investigate the effect of food quality, and rate of conversion on the growth of the developmental stages fed only on larvae of *Culex* mosquito.

MATERIAL AND METHODS

Specimens of *Sphaerodema annulatum* F. were collected from Inland Fisheries Station, Chetpet, Madras, India and reared in the laboratory. The males over which the eggs were laid by the female were isolated from the tank. Eggs left on the back of the males were about 73% successful. On the eighth day of incubation, the eggs hatched out to first nymphal instars. They were separated individually to containers, having the water with 1.25% salinity and pH 8.5 as in natural habitat. The temperature of the aquarium water was maintained constant (28±1°C). Third instar of *Culex* mosquito were chosen as food to maintain the uniformity in food quality. A stem of *Hydrilla verticellata* PRESL. was kept in the container for shelter. The procedure was followed for all the nymphal stages.

The scheme of energy balance followed in the present work is that of the IBP formula (PETRUSEWICZ & MACFADYEN, 1970) represented as C = P+R+F+U where C is the amount of food consumed, P the growth including the exuvia, R the respiration, F the feaces and U the nitrogenous wastes.

Quantitative estimation of C was determined from the difference between the dry weight of the food given and that of the unutilized food. That of P is estimated by subtracting the dry weight of a nymphal instar a day after moulting from the dry weight of the nymph that has emerged out.

Data pertaining to rate of conversion was subjected to one way classification—many sample analysis of variance and Studentized range test (GOLDSTEIN, 1964). Measurements of total body length and individual organs of the natural and experimental populations were made at different stages of growth.

RESULTS

The animal sucks the substance from the food provided, leaving behind the unutilized food in the form of an empty pocket. During feeding, the food does not seep through the sides of the stylets. The unutilized food was collected and heated to dryness to estimate the dry weight.

Defaecation and excretion

Due to continuous feeding, the animal defaecates and it settles down in the containers The dry weight of the faeces is taken from the precipitate of the water that has been collected from the tank and centrifuged. Estimation of nitrogen of the supernatant by Microkjeldahl procedure (VAN SLYKE. 1932) revealed that the dissolved organic components of the faeces is very much negligible. It is also known that in majority of insects, the quantity of uric acid (U) in faeces is negligible (about 0.2% to 0.5% of the faeces energy—WALDBAUER, 1968; LAWTON, 1969). Hence the dry weight of the faeces centrifuged was substituted for the factor F in the IBP formula.

Growth

Measurements of the total body length of the nymphs of different instars recorded show variation between the natural and experimental populations (Fig. 1). A comparison of the morphometric measurements of the III nymph of the natural and experimental population would show a differnece. These differences are ascertained in the size of rostrum length, head width. I leg, II leg and III leg (unpublished data). Another interesting feature is that the period of post embryonic development is extended to 82 days on an averge in the experimental population when compared to 45 days in the natural population (Fig. 2).

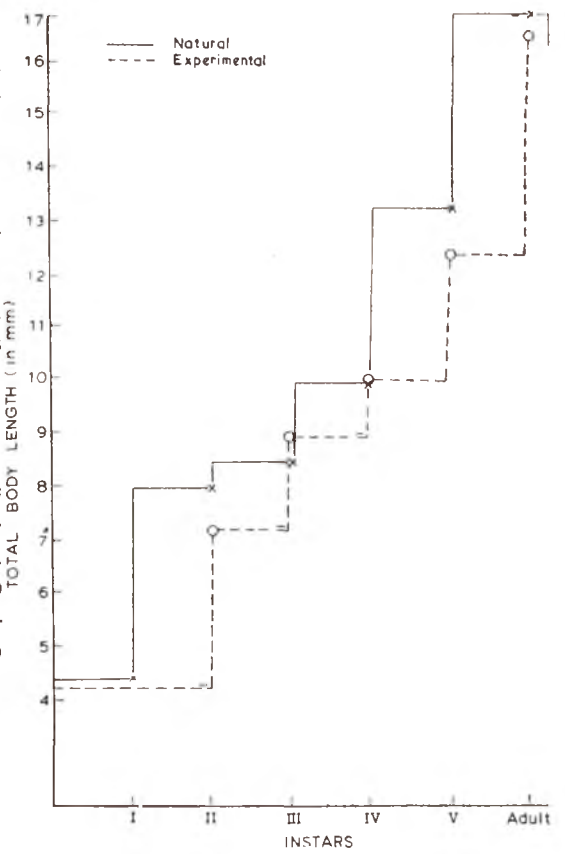

Fig. 1. Graphic representation of growth variation among natural and experimental animals.

Energy budget in experimental animals

The results pertaining to energy budget reveal that – 0.8 mg dry weight of the first

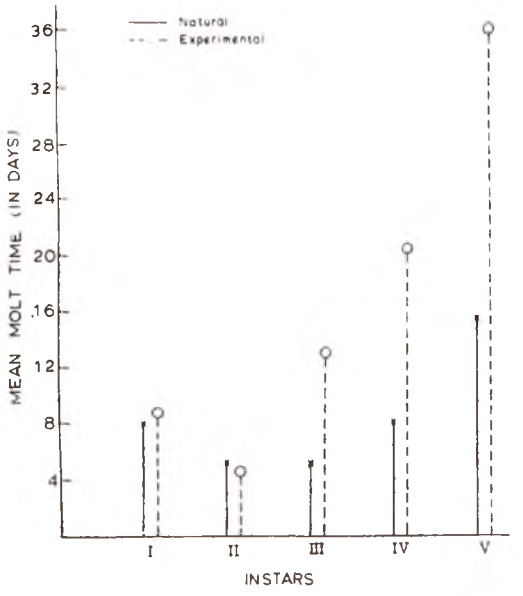

Fig. 2. Duration of nymphal stages.

nymph increases upto a maximum of 28.0 mg at the final nymph after passing through five stages. Further, the rate of feeding from I instar to V instar range from 5983.0 mg dry weight/g live insect/day to 566.1 mg dry weight/g live insect/day. Table 1 reveals that the assimilation efficiency and rate of assimilation remain constant in all the nymphal stages. Although the food was assimilated equally, the rate of conversion and conversion efficiency varied significantly. Statistical analysis of variance in the rate of conversion has been carried out and their significance were graded. It shows that II instar (2617.8) is superior to their neighbours in the rate of converision and I instar (834) is significant to that of IV instar (–587.51) and V instar (–393.3). No other comparison is significant. A comparison of the rate of feeding, assimilation and conversion is presented in Table 1. It indicates that food quality affects the converision efficiency and conversion rate at II instar. In spirte of the short duration of the II instar, the conversion rate remains higher which is reflected in the size of the III instar to which it has emerged.

DISCUSSION

From the above observations, it may be suggested that the selective food quality has

TABLE 1. Comparison of conversion efficiency, assimilation efficiency, conversion rate, assimilation rate and feeding rate during the post embryonic stages of *Sphaerodema annulatum* Fabr. fed with larvae of *Culex* mosquito.

Sl. No.	Instar	Conversion Efficiency %	Assimilation Efficiency %	*Conversion Rate	Assimilation Rate	Feeding Rate
				(mg dry wt / g live insect / day)		
1.	I	2.950 ±.642	97.05 ±.642	183.4 ±74.86	6020.0 ±1706.5	5983.0 ±1837.4
2.	II	4.903 ±.53	95.05 ±.772	274.470 ±34.87	4732.0 ±1098	5495.0 ±1156
3.	III	3.512 ±.5336	96.13 ±.3777	95.102 ±9.929	2228.6 ±367.92	2480.2 ±350.21
4.	IV	7.089 ±.209	92.91 ±.3409	43.86 ±4.249	620.9 ±26.191	649.5 ±52.341
5.	V	6.12 ±.55	93.88 ±.656	34.45 ±6.628	545.6 ±94.53	566.1 ±96.177

*Anova: F=2.61 that differed significant at P=0.05 level.

influenced the total body length and allometric growth of variours organs through energetics—the conversion efficiency, conversion rate, assimilation efficiency and assimilation rate in the experimental population. This finding suggests that the type of food has an impact on the life span and survival value of the animal. Furthermore this increased duration of instars of *S. annulatum* fed with mosquito larvae indicates that mosquito larvae form an ideal prey for *S. annulatum* suggesting its possible utilization in the control of mosquito larvae.

PANDIAN & MADHAVAN (1975) attribute the prolonged life span of aquatic larvae to the probable consequence of low feeding rate. But work of BLUMBERG & SWIRSKI (1974) on the predatory rates of the larvae and adults of *Cybocephalus micans* and *C. nigriceps* abundantly supplied with food indicate that only a small amount of prey is required by them to complete their development, to reproduce and to survive. Therefore factors other than the quantity of food may play a role in prolonging the life span.

The results further reveal that the second nymphal instar shows potential conversion efficiency than the first instar and the conversion efficiency is maintained in gradiance in other stages. This increased duration of the postembryonic period indicate that the mosquito larvae may be an ideal prey for *Sphaerodema annulatum* F. and hence *S. annulatum* may be used for the control of mosquito in their larval period.

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SURVEY OF BENEFICIAL ARTHROPODA IN THE COTTON ECOSYSTEM AT COIMBATORE, SOUTH INDIA

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Twelve predators and twenty one parasites are recorded from the cotton ecosystem of Coimbatore region in South India; of these six, predators and fourteen parasites are reported for the first time on cotton pests from this region. Sucking pests like aphids and thrips are effectively checked by their predators but not the boilworms, *Pectinophora gossypiella* (SAUND) and *Earias* spp., bollworms escape from the predators by remaining inside the bolls. Parasites of bollworms also do not effectively check their host species as they emerge in abundance only during late bolling phase when the boilworms have sufficiently damaged the crop.

(*Key words :* **beneficial arthropods; cotton ecosystem**)

INTRODUCTION

A survey of naturally occurring beneficial arthropods was made to augment the known list of beneficial organisms in pest control strategy as agents of biological control in the integrated pest management programmes for cotton in South India. Many parasites of cotton pests were reported by earlier workers in India. NANGPAL (1948) enumerated one egg–, twelve larval and two pupal parasites and one spider as predtor on pink boll worm, *Pectionophora gossypiella* (SAUND.) and one egg–, eight larval and seven pupal parasites on the different species of spotted bollworms, *Earias* spp., all from Punjab (North India) and Marathwada region of Central India. In addition, THOMPSON (1945) recorded *Phanerotoma handecasisella* CAM. as a larval parasite on *E. insulana* BOISD. from North India. KHAN & RAO (1960) catalogued as many as twenty one predators on *Aphis gossypii* GLOV. They also listed *Thripoctenus brui* VUILLET as parasite and the anthocorid *Triphelps tantilus* MOTASCH and a camspid mite as predators on *Thrips tabaci* LIN. from Central India. MISRA (1921) recorded the same anthocorid to be predator on dusky cotton bug, *Oxycarenus laetus* KIRBY at Pusa (North India). From South India, AYYAR (1928) noted *Chelonus* sp. and CHERIAN & KYLASAM (1941) reported *Goniozus* Sp., *Microbracon gelechidiphagus* RAM. AYYAR and *Apanteles pectinophorae* as an underscribed parasite on pink bolloworm. NANGPAL (1948) in his earlier catalogue listed five larval parasites on *Earias* spp. from Madras (South India). This paper gives the idntified list of predetors and parasities of cotton pests from Coimbatore region, S. India. Six predators and fourteen parasites are reported here for the first time from cotton ecosystem.

MATERIALS AND METHODS

Specimens were collected by several collecting procedures viz., hand picking, netting, host rearing and light trapping. Predatory species were collected directly from the field during daily routine observation of the crop: they were brought alive to the laboratory and reared in petri dishes and glass cages to assess their predatory efficiency and prey preference. Routine observations were also made on these predators in the field to assess their distribution and population dynamics. Parasitic

species and their incidence were recorded by rearing the host material collected from the field in the laboratory. All study on the intensity, distribution and population dynamics of the predatory and parasitic species were made from insecticidally unprotected cotton fields.

RESULT AND DISCUSSION

Details of predatory and parasitic species and their prey or host identified from Coimtore region are presented in Tables 1 and 2 respectively. It is noted that the predators are polyphagous. Coccinellids, mantids and syrphids together exercise good control over the sucking pests like aphids and thrips, but the bollworms escape the attack of the spiders when they remain inside the bolls and the spiders prey on them only when these bollworms move out of the bolls. Therefore, predators are not very effective control agents for bollworms. Parasites of bollworms are found to be abundant during two seasons viz., February-March and July-September; late bolling phase of winter and summer cotton respectively. Most damage due to bollworms is caused during early squaring and bolling phase and hence the parasites of bollworms appearing in abundance at later stage of the crop is of less value and hence it needs more intensive study to utilise the parasites more effectivly in biological control of bollworms. It is also noted that the predators and parasites of cotton pests are found in meagre number in fields treated with insecticides, when compared with the untreated fields, hence judicious application of specific pesticides in proper time will save these beneficial

TABLE 1. List of predators from cotton ecosystem at Coimbatore 1973–77.

Order	Family	Predatory species	Prey species
Arachnida	Araenidae	* *Dianycha* sp.	*Pectinophora gossypiella* (Saund.)
		* *Peucetia viridanus*	*P. gossypiella*
			Oxycarenus laetus Kirby.
	Phytoseeidae	*Amblyseius* sp.	*Tetranychus telarius* Linn. (Red spider mite)
Coleoptera	Coccinellidae	*Coccinella septumpunctata* L.	*Aphis gossypii* Glov.
		Menochilus sexamaculatus (F.)	*A. gossypii*
		Scymnus	*A. gossypii*
Dictyoptera	Mantidae	*Mantis* sp.	*A. gossypii*
Diptera	Syrphidae	* *Xanthogramma* sp.	*A. gossypii*
		* *Orius minutus* (L.)	*Scritothrips dorsalis* Hood
	Lygaeidae	* *Geocoris tricolor* Fabr.	*O. laetus*
	Reduvidae	* *Pasira perpusiella* Walk.	*O. laetus*
Neuroptera	Chrysopidae	*Chrysopa carnea* Steph.	*A. gossypii*

* New record on the pest noted against from Coimbatore region, S. India.

TABLE 2. List of parasites reared from cotton pests at Coimbatore 1973–77.

Host species	Stage of host	Parasite[1]	Period of abundance
Pectinophora gossypiella	larval instars III & IV	*Apanteles angaleti* Muesb. (Braconidae)	February, March, July August and September
	II & III	*Bracon greeni* Ashm. (Braconidae)	August and September
	III & IV	*Camptothlipsis* Sp. nr. *antigastrae* Wilk. (Braconidae)	(rare)
	II & III	* *Chelonus cycloporus* Franz. (Braconidae)	(rare)
	II, III & IV	* *C. versatilis* Wilk. (Braconidae)	July, August & September.
	III & IV	*Goniozus* sp. (Bethylidae)	July, August and September.
	III & IV	* *Tetrastichus nyemitrus* Rohver (Eulopidae)	(rare)
Earis	Egg	*Trichogramma* sp. (Trichogrammatidae)	November–December
	All larval instars	*Rhoges aligharensis* Quadri (Braconidae)	October and November
		* *Aphanogamus manilae* Ashmead (Ceraphoranidae)	(rare)
	Pupa	* *Agathis* sp. (Braconidae)	July-September
	Pupa	*Melcha nursei* Cam. (Ichneumonidae)	(rare)
Aphis gossypii	Adult	* *Aphidencyrtus aphidivorus* Mayr (Encyrtidae)	July–September
		* *Eucoilidae* sp. (Cynipidae)	July–September
		Trioxys indicus Subba Rao and Shaman (Braconidae)	July–September
Nazara viridula L.	Egg	* *Trissolcus* Sp. (Scelionidae)	July–September
Pseudococcus sp.	Adult	* *Anagyrus pseudococci* Girault (Encyriidae)	(rare)
		* *Anastatus* sp. Eupelimade	(rare)
		* *Cheiloneurus* sp. (Encyrtidae)	(rare)
		* *Dendrocercus* (Ceraphronidae)	(Rare)
		* *Marieta exotiosa* compare (Aphelinidae)	(rare)

* First record from cotton ecosystem in Coimbatore region, S. India.
[1] The respective family of the parasite is given in parantheses under specific name.

organisms which will definitely play a key role in limiting the pest population.

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BRIEF COMMUNICATION

EFFECT OF STARVATION, MATING, OVARIECTOMY AND JUVENILE HORMONE ANALOGUE ON INDIRECT FLIGHT MUSCLE HISTOLYSIS IN *DYSDERCUS CINGULATUS*

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A brief report on the influence of mating, starvation, ovariectomy and the JH analogue Kinoprene (ZR 777) on flight muscle histolysis in *Dysdercus cingulatus* is given. Mating and feeding are essential for histolysis of flight muscles in females. Males are however unaffected. Ovariectomy prevents degeneration to some extent. JH analogue, topically applied, induces degeneration in males as well as starved virgin females.

(*Key words: Dysdercus cingulatus*, **flight muscle histolysis, mating, starvation, ovariectomy, JH analogue**)

Flight muscle histolysis has been reported chiefly from Diptera, Heteroptera, Homoptera, Coleoptera and Isoptera (FINLAYSON, 1975). Females of many *Dysdercus* sp. are known to histolyse the flight muscle during the first gonotrophic cycle. EDWARDS (1966 a, b; 1970) studied flight muscle degeneration in *Dysdercus intermedius*. DINGLE & ARORA (1973) found histolysis in *D. fasciatus*, *D. nigrofasciatus* and *D. superstitiosus*. DAVIS (1975) investigated the hormonal control of flight muscle histolysis in *D. fulvoniger*. The present communication is a summary of the studies on flight muscle histolysis in *D. cingulatus* so far conducted in our laboratory.

Newly emerged adult *Dysdercus cingulatus* were isolated from the stock colony and thus insects of known age were available whenever required. Animals were maintained in the laboratory as already described (JALAJA & PRABHU, 1976). The dorsal longitudianal muscles of the thorax were studied as they had easier access.

Different categories of animals, 10 – 20 each, were studied as shown in the Table. For starvation experiments, insects were given only distilled water. Females on emergence were isolated, given 5% sucrose solution and allowed to remain virgin for 6 days. They were tested for flight ability which was an indication of the presence of well developed flight muscles. Those which could fly were used for groups 10, 11, 12 and 13 (Table) and were sacrificed 5 days later. The latter group served as control for the 10th, 11th and 12th groups.

Juvenile hormone analogue, "Kinoprene" (ZR 777) (1 μg per 1 μl acetone per insect) a gift from Dr. G.B. STAAL of Zoecon Corporation, was topically applied to the abdominal tergum of '0' day males (Group 14) and 1 μl pure acetone was applied to the control insects. The animals were sacrificed after 4 days. Similar JH treatment was given to '0' day females and they were starved and allowed to remain virgin for 5 days when they were sacrificed (group 15). Control females were treated with 1 μl pure acetone.

The animals were sacrificed and the diameter of muscle fibres was measured as follows. The dorsal longitudianl muscles

TABLE 1. Influence of mating, starvation, JH analogue and ovariectomy on indirect flight muscles of *Dysdercus cingulatus*.

Group	Experiment	Percentage of animals with:	
		Fully[2] or partially[3] degenerate muscles	Non-degenerate[4] muscles
1	1 day to 7 day old fed females with free access to males[1]	100% in 4 to 7 day old insects	100% in 1 to 3 day old insects
2	1 day and 7 day old fed males with free access to females[1]	nil	100%
3	Fed, virgin females	40%	60%
4	Starved, virgin females	nil	100%
5	Starved, mated females	75%	25%
6	Starved, virgin males	nil	100%
7	Starved, mated males	nil	100%
8	Fed, virgin males	nil	100%
9	Ovariectomised, fed and mated	64%	36%
	Sham ovariectomised control	100%	nil
10	Virgin female fed sugar 6 days, then fed cotton seed 5 days	57%	43%
11	Virgin female fed sugar 6 days, then allowed to mate and again fed sugar 5 days	89%	11%
12	Virgin female fed sugar 6 days then fed cotton seed 5 days and allowed to mate	100%	nil
13	Virgin female fed sugar 11 days	nil	100%
14	JH treated males, fed and mated	100%	nil
	Control	nil	100%
15	JH treated, starved, virgin females	100%	nil
	Control	nil	100%

[1] Mating starts 2 days after eclosion.
[2] diameter of muscle fibre less than 15μ.
[3] diameter of muscle fibre above 15μ but less than 30μ.
[4] diameter of muscle fibre 30μ or more.

were dissected out from insects immersed in Ringer solution and stained in 0.5% aqueous methylene blue for 5 minutes. In the non-degenerate condition the muscle fibres dissociated at the slight pressure of a needle. In degenerate muscle, fibres had to be separated by teasing with needles. The stained muscles were kept in a drop of Ringer solution and immediately examined under microscope. The diameter of 10 fibres from each animal was measured using a calibrated ocular micrometer. Data was statistically analysed using Student's t–test.

Decrease in diameter of muscle fibre is taken as a parameter of muscle histolysis. Our main findings are summarised in the Table. The present studies show that the flight muscles grow in size till 3 days after eclosion. Degeneration of flight muscles is clear from 4 day old fed, mated female *D. cingulatus*. Histolysis is almost complete in such 7 day old females. These histolytic changes begin concomitant with the beginning of vitellogenesis in *D. cingulatus* (JALAJA & PRABHU, 1971). By the time the first batch of eggs is laid, the flight muscles are maximally histolysed.

Mean fibre diamter of 1 day old and 7 day old males show no statistically significant difference at 1% level. So histolysis of flight muscles does not occur in the male. This is so in *D. intermedius* (EDWARDS, 1969a) *D. fulvoniger* (Davis, 1975), *D. fasciatus, D. nigrofasciatus* and *D. superstitiosus* (DINGLE & ARORA, 1973).

Histolysis does not occur in 60% of the fed virgin female *D. cingulatus*. DAVIS (1975) reports a low incidence of histolysis in fed, virgin females of *D. fulvoniger*. This suggests that mating is essential for degeneration in 60% of the females. Starved virgin females retain the flight muscles. But mating induces degeneration in 75% of the starved *D. cingulatus* females. A similar effect of mating is reported in *D. intermedius* (EDWARDS, 1969b). But in D. *fulvoniger* (DAVIS, 1975), *D. fasciatus, D. nigrofasciatus* and *D. superstitiosus* (DINGLE & ARORA, 1973) mating has no such effect in inducing muscle histolysis. In *D. cingulatus,* feeding sucrose solution has the same effect as that of starvation on muscle degeneration.

In this species, histolysis comparable to that of the controls occurs only in 14 per cent of ovariectomised insects although EDWARDS (1970) finds no effect of ovariectomy on muscle histolysis in *D. intermedius*. 36 per cent of the ovariectomised insects possess intact flight muscles. It appears that in female, mating, feeding and presence of ovaries play their respective role in flight muscle histolysis.

Fed virgin males, starved virgin males and starved mated males all possess normal flight muscles in this species. Males which do not histolyse their flight muscles under the variables tested, do so when juvenile hormone analogue is topically applied. All JH treated males histolyse their muscles 4 days later while control males possess intact muscles. Similarly, starved, virgin females treated with JH also histolyse their flight muscles while the control insects retain the muscles. Starvation has identical effects as that of allatectomy. JH is also responsible for muscle histolysis and JH induced histolysis in starved females is indicative of such a hormonal basis of flight muscle histolysis in *D. cingulatus*. A similar effect of JH is found in *D. fulvoniger* (DAVIS, 1975) and in the scolytid beetle *Ips confusus* (BORDEN & SLATER, 1968) where a cyclic degeneration and regeneration of the dorsoventral flight muscles take place (BORDEN & SLATER, 1969). In the Colorado potato beetle, *Leptinotarsa decemlineata,* allatectomy and removal of the postcerebral complex induce degeneration of the muscles. Reimplanation of the

same causes the thoracic muscles to regenerate (STEGWEE et al., 1963). In *Leptinotarsa* histolysis is associated with JH deficiency and ovarian diapause. In *Dysdercus* and *Ips*, JH promotes histolysis of flight muscles and in *Leptinotarsa* it promotes muscle growth Circumstantial evidence (JALAJA & PRABHU 1971) suggests that flight muscle degeneration is *Dysdercus cingulatus* is related to ovarian development.

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TWO NEW SPECIES OF *DIKRANEURA* HARDY (AUCHENORRHYNCHA, CICADELLIDAE, TYPHLOCYBINAE) FROM INDIA WITH REMARKS ON THE GENUS

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Two new species viz., *Dikraneura zlata* from Jaintia Hills and *D. grisea* from Simla are described. Three Palaearctic groups of species of the genus *Dikraneura* Hardy are distinguished and diagnostic features for the groups are given.

(*Key words:* **new species of *Dikraneura*, India**)

Five species of the genus *Dikraneura* Hardy are known from the southern Palaearctic. Four of these, *Dikraneura straminea* (Distant) from Darjeeling (Distant, 1918), *D. denticulata* Knight from Nepal (Knight, 1968), *D. knighti* Dwor. et Sohi and *D. apicta* Dwor. et Sohi, both from Ranikhet (Dworakowska & Sohi, 1978) can be distinguished as members of one group. The fifth species, *Dikraneura pakistaniensis* Ahmed (Ahmed, 1969) differs considerably and can be treated as a single representative of another group. The two new species described in this paper represent the third group.

The following features are characteristic of the *Straminea* group:

Terminal tooth of pygophore lobe almost straight, accompanied with membrane (Figs 3,4). Setae quite long, thin, grouped at dorsal margin of the lobe (Figs. 3,4). Subgenital plate with uniseriate row of macrosetae at about half of its length and with a sclerotized tubercle near apex (Fig. 5). Penis with two apical appendages and two pairs of other appendages below the gonopore on ventral side (Figs. 1,2) Hindmargin of VII abdominal sternite of female medially incised.

D. straminea (Distant) is the closest relative of *D. denticulata* Knight differing from it in having short and deeply bifurcated apical appendages at penis stem (Fig. 2), gonopore shifted apically, stout elongate processes are much larger while needle-like processes are rudimentary (Fig. 1).

So far this group is known from the Himalayan range and distribution is not yet known.

1. Dikraneura straminea (Distant 1918) (Figs. 1–5)

1 ♂, India, Darjeeling, Birch Hill, 1800–2100m, May 18, 1928, Coll. S. Ribeiro; 2 ♂♂, 2 ♀♀, Darjeeling, 2130m, June 8,1917, coll. Burnetti; 1 ♂, 1 ♀; Darjeeling(grasses, April 24, 1978, Coll. I. Dworakowska. The type specimens are deposited at the British Natural History Museum, London, Forest Research Institute, Dehradun and Punjab Agricultural Universiy, Ludhiana.

The characteristic features of the *Pakistaniensis* group, are:

The terminal tooth of pygophore side moderately developed, large stout setae grouped mainly in the terminal part of the

Figs. 1–11. *Dikraneura straminea* (Distant), 1–5, 1–Penis, side view, 2–penis, posterior view, 3–scheme of pigmentation and setosity of pygophore side and anal tube, 4–hindpart of pygophore side, 5–Proportions of subgenital plate, paramere, connective and 9th abdominal sternite of a male. *D. pakistanica* Ahmed: 6–11, 6–subgenital plate, 9–abdominal apodemes, 10– anal block.

lobe (Figs. 10,13). Macrosetae on subgenital plate forming on oblique row reaching up to tip of the plate (Fig. 6), the setae are more or less of equal size. Tip of penis stem is provided with very small lateral protrusions situated subapically and there is only one pair of lateral appendages at the level of lower margin of the gonopore (Figs. 7,8).

2. Dikraneura pakistaniensis Ahmed, 1969, Figs (6–15).

1 ♂, Pakistan, Muree, Kuldanna, 2135m, 11.xi.1928, H.S. Pruthi, 4 ♂♂, 2 ♀♀, with same label but collected on 13.xi. 1978, 1♂ 3 ♀ ♀, Murree, Jhika Gali, 2000m, 17.xi. 1928., H. S. Pruthi. All specimen deposited in the Zoological Museum, Uni-

Figs. 12–15, *Dikraneura pakistanica* Ahmed: 12–paramere, 13–pygophore side, 15–connective. 16–22, *D. grisea* sp. n. Figs. 23–24, *D. grisea* sp. n.

versity of Karachi. All collected by H.S. Pruthi in 1928.

Two species described below represent the *Grisea* group differing from *D. pakistaniensis* Ahmed due to well developed terminal tooth on side of pygophore, presence of a distinct protrusion at dorsal margin of pygophore lobe, subgenital plate with numerous macrosetae which vary in size and two pairs of appendages on ventral side of penis stem, one below and one above the gonopore.

3. Dikraneura grisea sp. nov. (Figs. 16–24)

Ground colour of body yellowish-testaceous suffused with brownish-grey. Vertex of male almost rounded at anterior margin, only slightly produced in the middle in female. Eyes blackish-brown. Hindmargin of VII abdominal sternum of female slightly produced and medially infuscated. Apex of vulva brownish-black.

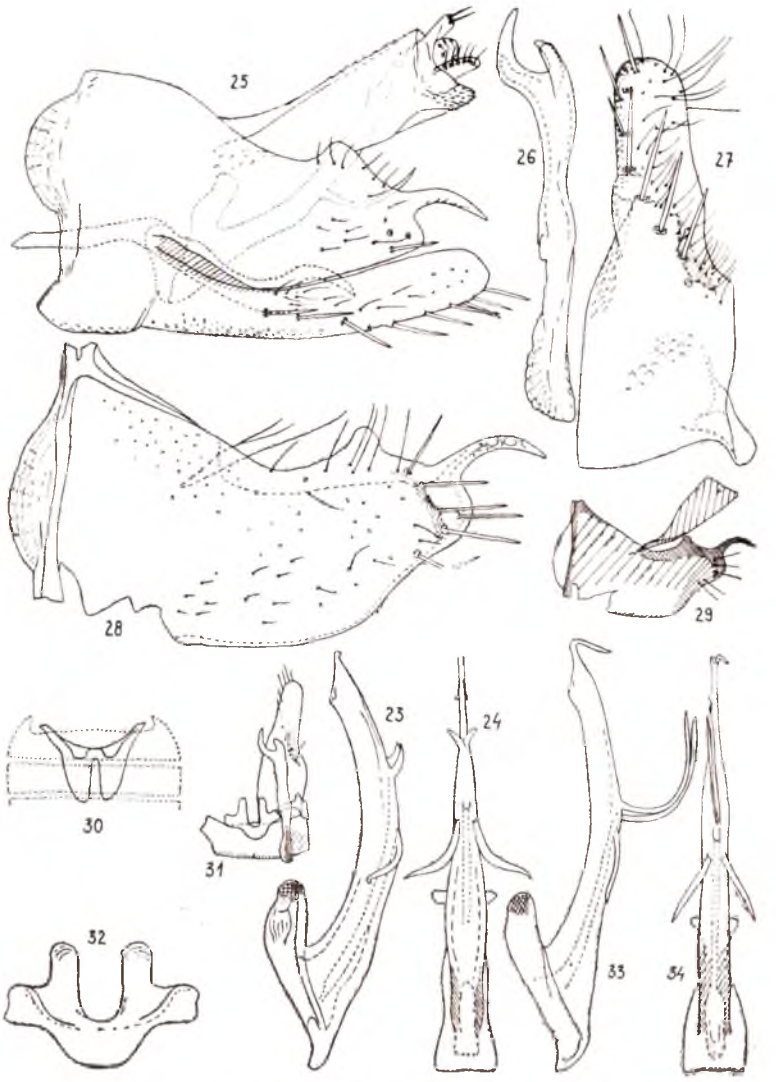
Terminal appendages of pygophore hooked (Fig.20), the dorsal extension very large

and well sclerotized (Fig. 16). Penis stem slightly arcuated (Fig. 23), laterally compressed in upper part, with two short and stout processes situated far from upper margin of gonopore and two larger processes directed laterally (Fig. 24). Length ♂ 3.8—4.0, ♀ 4.0—4.55mm.

Holotype male and **paratypes** 1, INDIA : HIMACHAL PRADESH, Simla clover and grasses, 30.iii. 1978, coll. Shatrughna Singh. The holotype and a part of paratypes deposited at Central Potato Research Institute, Simla, other paratypes at Staatliches Museum für Tierkunde in Dresden and at the Zoologisches Museum der Humboldt Universität in Berlin (D.D.R).

4. Dikraneura zlata sp. n. (Figs 25–34).

Body comparatively robust. Vertex produced in the middle, rounded terminally.



Figs. 25–34 *D. zlata* sp. n.

Ground colour greenish-yellow. Eyes black-yellowish. In some specimens there is an ochre tint on pronotum and basal triangles. Whitish streak in the middle on upper side of body not visible. Forewing hardly semitransparent, suffused with yellow and clavus and longitudinal cells. Apical cells slightly greyish.

Terminal appendage of pygophore slightly curved, ornamented with ledges (Fig 28), dorsal extension tuberculate (Figs 25,28,29). Penis stem almost straight, terminated in a bifurcated process. There are two slightly asymmetrical long arcuate processes arising just at upper margin in the gonopore (Fig 33). Two almost straight shorter processes are situated far from lower margin of gonopore directed laterally (Fig 34). (Length ♂ 3.5, ♀ 3.9—4.0m.)

The new species differs from the previous one by features mentioned in both descriptions especially by penis structure. Penis stem in *D. zlata* is almost straight when seen in side view while in *D. grisea* it is distinctly arcuate. Upper penis processes and processes above the gonopore are long in *D. zlata* and short in *D. grisea* and the processes below the gonopore are shorter in species just described in comparison to those of *D. grisea* sp. n.

Holotype male and **Pratype** 1, INDIA: MEGHALAYA, Shillong, grasses, 19.iv. 1978, coll. I. Dworakowska.

The holotype and one female paratype are deposited at Staatliches Museum für Tierkunde, Dresden (D.D.R). The other paratypes in the British Museum (Nat. Hist.), London.

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A NEW SPECIES OF *BALOCHA* (HOMOPTERA : CICADELLIDAE) FROM DELHI

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(*Received 24 October 1978*)

Balocha bifurcata sp. nov. (Cicadellidae) is figured and described from Delhi on the trees of Jamun (*Eugenia jambulana*).

(*Key words:* **Homoptera, Cicadellidae, Idiocerinae,** *Balocha bifurcata* **sp. nov. from India)**

Distant (1908) described the genus *Balocha* with *Balocha tricolor* as the type from Burma. Maldonado Capriles (1961, 1964) transferred *Idiocerinus melichari* Baker and *I. nacreatus* Baker (both from Philippines) and *Idiocerus astutus* Melicher (from South India) to this genus. He also described *Balocha lucida* and *B. bicolor* from Borneo. *B. pallida* from Pakistan, *B. maculifrons* and *B. pseudomaculifrons* from New guinea and *B. unilineata* from New Britain (Maldonado Capriles, 1961, 1968 and 1970). The description of a new species of *Balocha* discovered recently is given below and it can be separated from all the rest of species of *Balocha* according to the key given separately.

All the figures were drawn with a prism type camera lucida except wings which were drawn with a microprojector. The magnification lines were drawn to 1.0 mm in case of wings and to 0.2 mm for the rest of the parts.

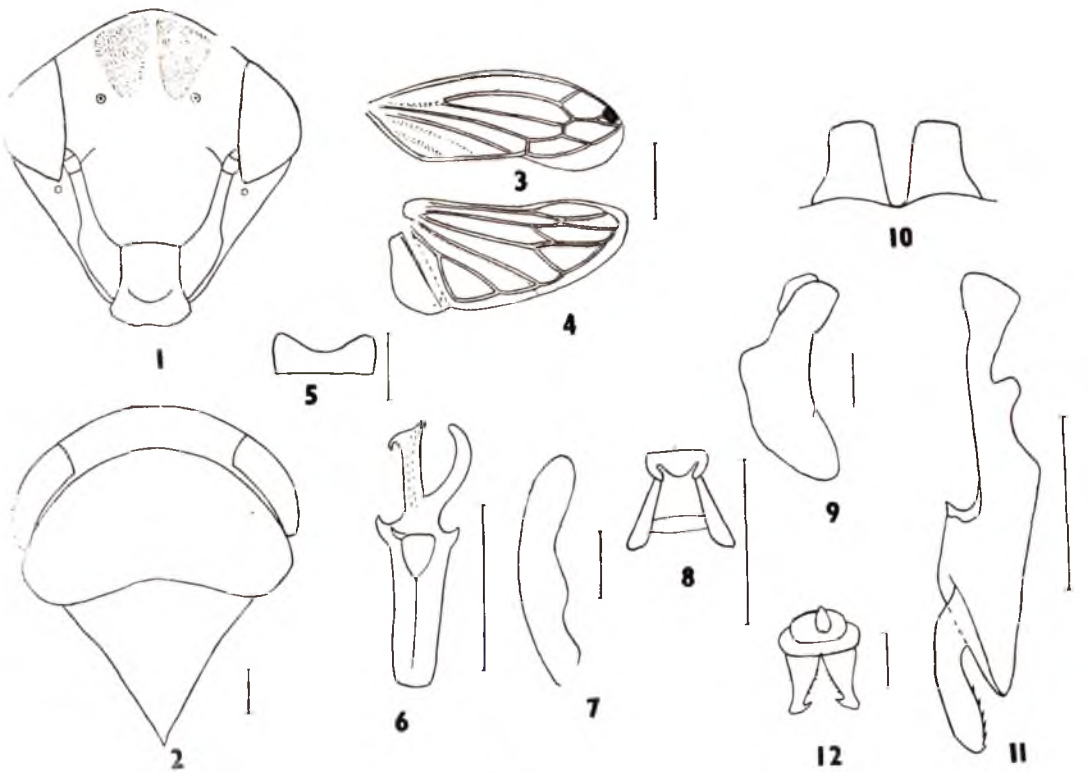
1. Balocha bifurcata sp. nov. (Figs. 1–12).

Yellowish orange leafhoppers possessing four apical cells with the third cell pedunculate and the absence of subapical cells in the forewing due to which the species are assigned to the genus, *Balocha* Distant instead of to a related genus, *Balocerus* Freytag and Morrison which has normal forewing venation. Though both the genera are similar in having similar type of aedeagus they differ externally in the venation of the forewing as above and internally in the shape of subgenital plates which are spatulate in *Balocha* (Maldonado Capriles, 1961) while they are large and paddle-shaped in *Balocerus* (Freytag and Morrison, 1972).

Face (Fig. 1) slightly longer than broad, ocelli more removed from each other than from eyes.

Forewing (Fig. 3) with pedunculate cell (third apical) possessing a piceous spot which spreads to the fourth apical cell also.

VIII sternum (Fig. 5) narrow with anterior margin concave. Subgenital plate (Fig.7) long, slender and upcurved. Pygofer (Fig. 9) in the middle and narrowed at ends. Paramere (Fig. 11) elongated with its cephalic portion ending into a flattened fan-like portion, and the caudal portion with two arms, connective (Fig. 8) sub-triangular with the apex, folded. Aedeagus (Fig.6)



Figs. 1–12 | *Balocha bifurcata*, sp. nov. ♂ 1, Face, 2, Vertex, pronotum & scutellum; 3, Forewing; 4, Hindwing; 5, viii sternum; 6, Aedeagus; 7, Subgenital plate; 8, Connective; 9, Pygofer lobe; 10, Abdominal apodemes; 11, Paramere, 12, anal ring.

with a long cylindrical preatrium, aedeagal shaft narrow, cylindrical with two small tooth like processes on the anterior upper angle, atrial apodeme present, gonopore apical.

Abdominal apodemes (Fig. 10) broad at the base and apex truncate with angles rounded.

Measurements in millimetres: Length 4.18; Forewing 3.46; Scutellum 0.86.

Holotype: ♂, INDIA: DELHI: 26.ix. 1939, H.S. Pruthi at light (wings and genitalia on slides and rest on tag).

Paratypes: 4♂♂, INDIA: DELHI: 1.x. 1956, Menon, on *Eugenia jambulana;* 10.xi. 1974 and 28.i.1975, P.K.R; on *Eugenia jambulana*.

Remarks: The species resemble *B. lucida* but can be separated from the same and all the other species of the genus in having a bifurcate type of aedeagus.

The type material is deposited in National Pusa Collections, I.A.R.I., New Delhi-110012.

KEY TO THE KNOWN SPECIES OF *BALOCHA*

1. Median longitudinal vein in the forewing blackened.....2
—Median longitudinal vein not blackened.....3

2. Subgenital plate laterally with projection ..... *B. unilineata*

—Subgenital plate laterally without any projection 4

3. Round spot in the pedunculate cell absent ..... *B. astutus*
—Round spot in the pedunculate cell present 5

4. Scutellum whitish characteristically..... ..... *B. melichari*
—Scutellum not whitish characteristically..... 6

5. With an invested yellow arc across face including ocelli ..... *B. tricolor*
—Without invested yellow arc across face including ocelli..... 7

6. Pedunculate cell of the forewing in the male with a very short peduncle (1:9)..... ..... *B. maculifrons*
—Pedunculate cell of the forewing in the male with slightly long peduncle (7:6)..... ..... *B. pseudomaculifrons*

7. Round spot in the pedunculate cell of forewing extends to the neighbouring apical cell..... 8
—Round spot in the pedunculate cell of the forewing does not extend to the neighbouring apical cell..... 9

8. Round spot in the pedunculate cell of the forewing brown; lateral margins of frons roundly angled; aedeagal preatrium shorter than the aedeagal shaft..... *B. bicolor*
—Round spot in the pedunculate cell of the forewing black; lateral margins of frons not roundly angled; aedeagal preatrium longer than the aedeagal shaft..... 10

9. Shining pearly, veins of the forewings basally orange; hindmargin of the anal segment of the female medianly produced and emarginate..... *B. nacreatus*
—Pale straw coloured; veins of the forewing concolorous on basal half of the wing; hindmargin of the anal segment of the female emarginate..... *B. pallida*

10. Aedeagus simple with bulbous aedeagal shaft and without atrial apodeme....*B. lucida*
—Aedeagus bifurcate with narrow and cylindrical aedeagal shaft and with atrial apodeme (fig. 6)..... *B. bifurcata* sp. nov.

Acknowledgements:—The authors are thankful to Dr. N.C. PANT, former Head of the Division of Entomology, IARI for the facilities provided.

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Entomon, 1979, *Vol.* 4, *No.* 3, *pp.* 299 *to* 301

A NEW GALL-MIDGE (DIPTERA : ITONIDIDAE : LESTREMIINAE) FROM INDIA

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(*Received 28 December 1978*)

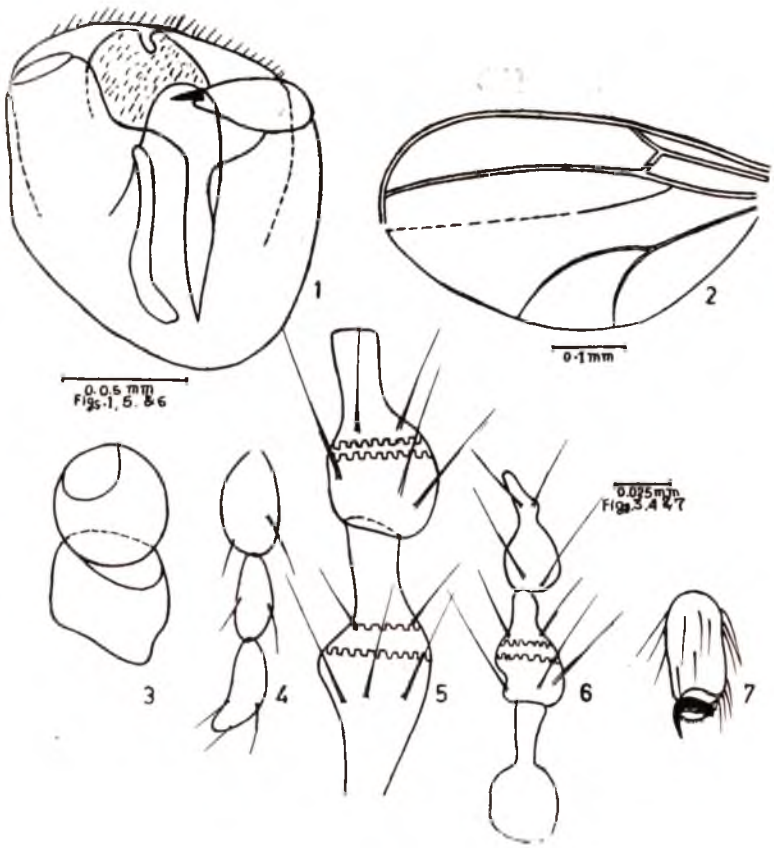
A new species *Xylopriona indica*, is described and the genus is recorded for the first time from India. A known species *Peromyia bangalensis* Kieffer is reported from Aurangabad, Maharashtra State.

(*Key words:* **gall-midge taxonomy, new species, India**)

1. Xylopriona indica, sp. nov.

Description of male

Body 1.34 mm long. Eyes confluent above. Ocelli absent. Trophi normal. *Palpus:* triarticulate, moderately long, sparsely setose; first segment (21:11) cylindrical, stout, a little less than 2.00 × its maximum thickness; second segment (17:8) cylindrical, shorter and thinner than first, length 2.12 × its maximum thickness; third segment (20:6) longer and thinner than second, length 3.33 × its maximum thickness. *Antenna:* longer than body, with 2+16 segments, flagellate segments cylindrical with long special stems, enlargements with two whorls of long setae and two rows of peculiar sensoria; as in figure, distal segments gradually thinning towards the tip; scape (14:25) rectangular, wider than long; pedicel (15:15) globose; third segment (50) not confluent with but longer than fourth, with a very small basal prolongation (5:7), enlargement (25:22) 0.50 the length of the segment and 1.13 × its maximum thickness, stem (20:9) 0.80 the length of the enlargement and 2.22 × its maximum thickness; fourth segment (40) with enlargement (23:21) 0.57 the length of the segment and 1.09 × its maximum thickness; stem (17:9) 0.73 the length of the enlargement and 1.88 × its maximum thickness; fifth segment (38) shorter than fourth, englargement (22:21) slightly less than 0.60 the length of the segment and 1.04 × its maximum thickness, stem (16:8) 0.72 the length of the enlargement and 2.00 × its maximum thickness, sixth segment (40) longer than fifth; seventh to ninth segment (38) similar but shorter than sixth; tenth to twelfth segments (40) similar but longer than ninth; thirteenth segment (38) shorter than twelfth; fourteenth segment (36) shorter than thirteenth; fifteenth and sixteenth segments gradually reduced in length; penultimate segment (20) shortest of all, enlargement (11:14) 0.55 the length of the segment and wider than long, stem (9:3) 0.81 the length of the enlargement and 3.00 × its maximum thickness; terminal segment (22) longer than penultimate, enlargement (14:11) 0.63 the length of the segment and 1.27 × as long as thick, stem in the form of an apical nipple-like prolongation (8:8), which is 0.57 the length of the enlargement and as long as thick. *Wing:* (60:32) neither too long nor too broad, hyaline, 1.87 × as long as broad; vein R_1 meeting costa slightly beyond the basal 1/4 of the wing and 4.00 × the length of the vein R_{s}, later distinct and oblique, two sensory pores, one on the distal end of vein R_s



Xylopriona indica, sp. nov. ♂ Fig. 1. Genitalia (ventral view), 2. wing, 3. scape and pedicel, 4. palpus, 5. third and fourth antennal segments, 6. terminal three antennal segments, 7. claw.

and other on the vein R_5, later uniting costa beyond apex, and costa continued beyond the union of vein R_5, vein M_1 complete, vein C_u forked. *Legg:* long, densely hairy, tarsi clothed with long and short bristles; metatarsus (19) longest of all, nearly 2.00× the length of the terminal tarsal segment and shorter than the rest of the segments combined together (40); claw evenly curved; empodium slightly shorter than claw (9:10). *Genitalia:* pale-brown, sparsely setose, basal clasp segment (40:28) enlarged medially, length 1.43 × its maximum thickness; terminal clasp segment (20:7) gradually tapering towards the tip and ending in a strong spine, 0.50 the length of the basal clasp segment and a little less than 3.00 × as long as thick; dorsal plate (40:44) broad, entire, wider than long; subdorsal plate (15:40) shorter than dorsal plate, broadly rounded apically, notched in the middle, wider than long; tegmen (30:13) shield-shaped, rounded apically, 2.30 × as long as broad, longer than genital rod; later (26:4) slender, well sclerotized and 6.50 × as long as broad.

Female: Unkonwn.

Holotype: One ♂ dissected and mounted on slide, INDIA : MAHARASHTRA : Aurangabad Coll. R.M. Sharma, 6. vii. 1976. Kept in the Entomology Laboratory, Zoo-

logy Department, Marathwada University, Aurangabad.

Remarks: This species runs to the genus *Tetraxyphus* Kieffer (1913) but *Tetraxyphus* Kieffer is a synonym of *Xylopriona* Kieffer (1913), Pritchard (1947 a), and hence the species is described under *Xylopriona*. This genus is being recorded for the first time from India. Pritchard (1947 b) recorded three North American species viz., *X. crebra* Pritch., *toxicodendri* (Felt) and *articulosa* (Felt). But present species differs from these in the following characters : (i) different number of antennal segments, (ii) stems of the flagellate segments being as long as enlargements, (iii) antennal segments with two rows of peculiar sensoria, (iv) spine of terminal clasp segment not curved.

2. Peromyia bengalensis Kieffer

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1913. *Peromyia bengalensis* Kieffer, *Gen. Ins. fas.*, 152:292.
1920. *Peromyia bengalensis* Brunetti, *Rec. Indian Mus.*, 17:17.
1928. *Peromyia bengalensis* Senior-White *Cat. Ind. Ins. Pt.*, 15:19.
1934. *Peromyia bengalensis* Mani, *Rec. Indian Mus.*, 36(4):384.
1955. *Peromyia bengalensis* Rao, *Agra Univ. J. Res.*, 4(1):215.
1963. *Peromyia bengalensis* Grover, *Marcellia*, 31(2): 125.
1970. *Peromyia bengalensis* Grover, *Cecid. Indica*, 5(2) & (3):158.
1973. *Peromyia bengalensis* Gagne, *Cat. Dipt. Oriental Region*, 1:483.

Material: One ♀ dissected and mounted on slide, INDIA : MAHARASHTRA : Aurangabad, Coll. R.M. Sharma at light from Kharkeshwar, 27. ix. 1976.

This species was previously known from Bengal and is being reported for the first time from Aurangabad, Maharashtra State.

Acknowledgements:—Our thanks are due to the authorities of the Marathwada University, Aurangabad, for awarding a fellowship to senior author during his tenure of work.

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Entomon, 1979, *Vol.* 4, *No.* 3, *pp* 303 *to* 305

REPORTS AND NEW RECORDS

METEORIDEA HUTSONI (NIXON) (BRACONIDAE : HYMENOPTERA), A NEW LARVAL PARASITE OF *NEPHANTIS SERINOPA* MEYRICK (XYLORICTIDAE : LEPIDOPTERA)

Nephantis serinopa Meyrick, the black headed caterpillar pest of coconut in Kerala is parasitized by more than a dozen of parasites. This is the first record of *Meteoridea hutsoni* (Nixon) from the pupae of *N. serinopa* collected from Malabar (India) during 1977.

Meteoridea hutsoni (Nixon) was first described by Nixon (1941) in the name *Benama hutsoni* as a parasite of *Sylepta derogata* F. (Pyralidae).

The diagnostic features of the parastie are as follows: Head and thorax, except the propodeum, which is brown, honey yellow; petiole, tergite 2 (discrete), about basal half of 3, brownish. The brown patch on tergite 3 is subtriangular in the female, subquadrate in the male; rest of the abdomen honey yellow. Wings hyaline, the stigma almost colourless; the venation of the hindwing is very indistinct.

Face rather prominent beneath the antennal insertions, shining with rather feeble, isolated punctures which are also present on the clypeus. Eyes very large almost reaching the base of the mandibles, the malar space extremely short. Antenna with 28–30 segments. Mesoscutum falling rather steeply to the pronotum, strongly shining, smooth except for a few, isolated, small indistinct punctures. Abdomen long, narrow, the apex of tergite (2+3) and the following tergites compressed laterally. The

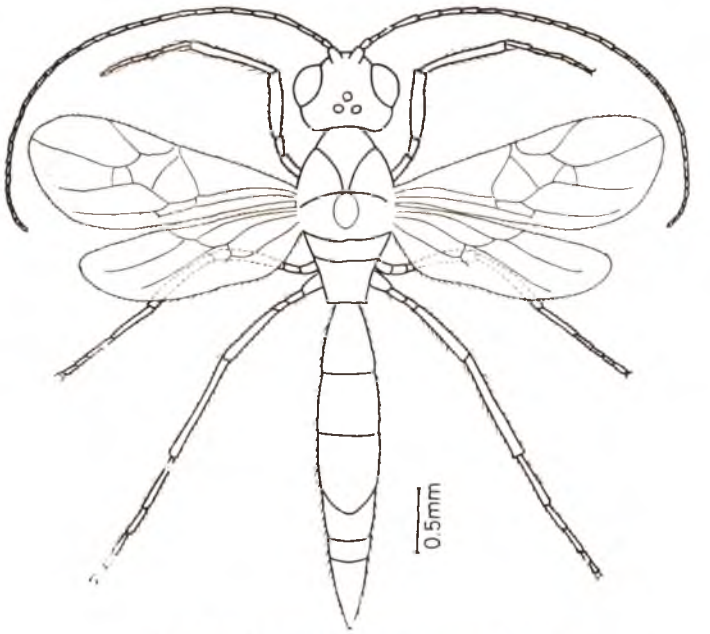

Fig. 1. Adult *Meteoridea hutsoni* (Nixon)

compressed apical part of the abdomen thickly clothed with long, pallid, bristly hairs. In male apex of the abdomen shows no lateral compression. The ovipositor is completely enclosed within the apex of the abdomen. Length, female: 3.3mm, male:3mm.

The percentage of parasitism seems to be low as so far only 49 parasites could be obtained, out of some 942 hosts collected from Malabar.

Material examined

Male and female Coll. No. PL1 and PL2 India; Kerala: Vengalam from *Nephantis serinopa* M. on 1977.

Acknowledgements:—Thanks are due to Dr. G.E.J. Nixon, Commonwealth Institute of Entomology, C/o. British Museum (Natural History), London, for identifying the specimen and to the United States Department of Agriculture for financial assistance under P.L. 480.

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INFECTION OF *NEPHOTETTIX VIRESCENS* (STAL.) (CICADELLIDAE : HEMIPTERA) BY *FUSARIUM EQUISETI* (CORDA) SACC.

The green jassid of rice *N. virescens* is important both as a pest and as a vector of virus diseases. During July-August, 1978 large number of dead adults and nymphs of *N. virescens* was observed in rice fields of the College of Agriculture, Vellayani. The fungal pathogen isolated in pure culture on potato dextrose agar from the dead insects was identified as *Fusarium equiseti*. Pathogenicity tests conducted by spraying a spore suspension prepared from 5 day old culture of the fungus showed cent per cent mortality of the nymphs and adults of the jassid. This is the first time this fungus is recorded as infecting *N. virescens*. *Beauveria bassiana* was earlier recorded as infecting the jassid (RAO, 1975).

The external symptoms of the infection were sluggishness and loss of appetite. Complete mortality occurred in 24 to 48 hours after inoculation. The cadavers turned pale green and hard to touch. External mycelial growth appeared 24 to 48 hours after death (Fig. 1).

The characteristics of the fungus in artificial cultures are as follows; mycelium septate, whitish to yellow to pink, aerial and cushiony. Microconidia one celled or

Fig. 1. *Fusarium equiseti* growing from the cadaver of green jassid

septate, oval or long disappearing with the occurrence of macroconidia which are borne on tubercular sporodochia, sickle shaped with thicker central portion and gradually tapering towards both ends. They are 3 to 6 septate. The average size of the conidia are given below:—

0—Septate— 5 to 18μ ×2.5 to 5μ
1—Septate—10 to 20 μ ×2 to 4 μ
2—Septate—10 to 25 μ ×2 to 4 μ
3—Septate—12 to 45μ ×2.3 to 5.5 μ
4—Septate—15 to 50μ ×2.5 to 5.5 μ
5—Septate—25 to 75μ ×2.8 to 5.7 μ
6—Septate—27 to 80μ ×2.8 to 5.9 μ

Fusarium equiseti has been earlier reported as a pathogen of pupae and adults of *Melanogromyza hibisci* Spencer from India (Sridhar & Krishniah, 1975).

Acknowledgement:—The authors are grateful to Dr. C. Booth, Commonwealth Mycological Institute, Kew, Surrey, England for identifying the fungus.

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BOOK REVIEW

Ecological Studies on *Trogoderma granarium* Everts and Methods of its Control, By A. S. Atwal & S. S. Bains, College of Agriculture, Punjab Agricultural University, Ludhiana. 137 pp.

This is the final technical report of a PL–480 project which functioned at the Punjab Agricultural University from 1969 to 1974. In this is reported results of comprehensive studies made on different aspects of the major storage pest of wheat in India. Survey undertaken in the Punjab has shown that distribution and extent of damage caused by the insect are governed by local weather conditions and type of storage used. Studies on the biology and ecology of the insects include observations on its seasonal biology, influence of temperature and humidity on its increase and survival, effect of variety of wheat on population buildup, dispersal and detailed studies on initiation, progress and termination of diapause in the insect. Population studies have been undertaken in relation to climate variation and depth of heaped grain; a high temperature of 25° C favours maximum multiplication of the species. Interspecific competition between *T. granarium* and other storage pests has been studied and whereever *T. granarium* assumes pest status the other insects are negligible. Results of trials made with different materials under the different environmental conditions for control of the pest have been presented and mixing the grain with powdered *neem* drupe and fumigating with aluminium phosphide give the best results. Based on trials conducted at different grainstores an integrated control programme for eradicating the pest from endemic stores and preventing reinfestation for prolonged periods has been formulated. Other items included in the Report are an account of the natural enemies of the pest, conclusions drawn from the studies, suggestions for additional research on the problem, a brief review of literature and a list of references.

The publication will be of use to students, research workers and extension specialists.

M. R. G. K. Nair

THE APHIDOLOGICAL SOCIETY OF INDIA

At the plenary session of "Symposium on Recent trends in aphidological studies" held under the auspices of Utkal University, Bhubaneswar and sponsored by University Grants Commission at Bhubaneswar (June 9–12, 1979) a society named "the Aphidological Society, India" has been formed to cater to the needs of scientists working on problems concerning aphids. The society intends to publish a newsletter and to hold periodical symposia, presently.

The office of the society is located at the Entomology Laboratory, Department of Zoology, University of Calcutta, 35 Ballygunge Circular Road, Calcutta–19.

For details of membership and other particulars, the interested persons are requested to contact the undersigned at the above address.

Sd/-
(A. K. Ghosh)
General Secretary

June 29, 1979.

ASSOCIATION FOR ADVANCEMENT OF ENTOMOLOGY
Department of Zoology, University of Kerala, Kariavattom,
Trivandrum 695 581

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Use only **metric units** as far as possible. Abbreviations of units should not be followed by full stop unless to avoid confusion.

References should be cited in the text by name(s) of author(s) and year of publication as: NAYAR (1958), or (NAYAR, 1958), NAYAR *et al.* (1970) etc. Abbreviate titles of periodicals according to *World List of Scientific Periodicals*, 4th ed., Butterworth, London (1963). The following style should be used for listing references:

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